JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

JULY, 1866.

CIVIL AND MECHANICAL ENGINEERING.

For the Journal of the Franklin Institute.

Grain Elevators, Cleaners, and Dryers. By ALFRED P. BOLLER, C. E.

The marvelous growth of the grain trade, during the last few years, has given rise to a department of construction for its handling, which it is the province of this paper to describe. To comprehend the necessity which resulted in the construction of grain elevators, it will, perhaps, be advisable to take a glance at this growth, and for that purpose the following statistics for the port of Buffalo are given. The amount of grain of all kinds brought to this port in 1840, was 1,075,888 bushels; in 1841, 1,852,325 bushels; and in 1842, it had grown to 2,015,928 bushels, which last amount was quadruple that received in 1836, a period of but six years back. All this grain had to be transferred from vessels to canal boats, or stored in warehouses along the docks, by means of manual labor, cumbersome tubs or bags being used for that purpose. Besides being slow and expensive, detaining both lake vessels and canal boats a long time in port, the grain trade had so developed, as to make it reasonable, from past experience, to look forward to a time. and that, too, not far distant, when it would be impossible to handle, by the old methods, but a very small proportion of the grain that would be poured into the port of Buffalo, from the fast settling west and north-west, seeking that port as an outlet for the Atlantic States and Europe. In view of these facts, and in the face of the sneers and evil prophecies that always attend an innovation upon long established custom, Joseph Dart, Esq., proposed to construct an elevating warehouse, the motive power for which should be steam. Accordingly, a small one was built, 50 by 100 feet, with a

storage capacity for about 55,000 bushels of grain, and with a transfer capacity of a little over 600 bushels per hour. So great was the success of this experiment that the enterprising builder increased its capacity so as to store 110,000 bushels of grain. A new period was now inaugurated in the grain trade, springing from Mr. Dart's success. Three more elevators were speedily commenced, improving, of course, upon the original one. In 1847, the grain trade had reached about 17,000,000 bushels, ten times the amount that was received in 1841, which large increase taxed the then existing facilities almost beyond their powers. To handle the sixty odd million bushels of grain which Buffalo now receives each year, there are twenty-four elevating warehouses, capable of storing 5,000,000 bushels, and a total transfer capacity of 2,350,000 bushels per day. The average storage capacity of these elevators is about 250,000 bushels each.

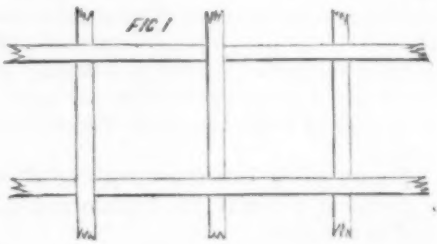
These warehouses are located upon the piers or docks, leaving sufficient room between them and the water's edge to allow a free passage way for drays and carts. This distance varies from 15 to 30 feet, surrounding circumstances, of course, regulating it. In plan, an elevator presents the appearance of a large rectangle, (formed by the outside walls,) broken up into numerous smaller ones, averaging from 10 to 12 feet square. These smaller rectangles are plans of the bins. When all the bins are full there is of necessity an immense weight to be supported. Some idea of this weight may be had from the fact that each 100,000 bushels of grain weighs 3000 tons, which would be for an elevator of 400,000 bushels capacity, 12,000 tons. It is easily seen how carefully the foundation for supporting such a weight must be prepared, and how guardedly any after-settling must be prevented.

From the necessitated location of grain warehouses on the wharves and piers, and the bottom being invariably mud and sand, there is but little choice for kind of foundation other than piles, upon which they are usually built. The piling, of course, must be most thoroughly done, and the piles should be driven as close together as it is possible to get them. They are cut off at least six inches below lowest water, and very carefully leveled. Upon the heads of the piles thus cut off, a course of heavy oak plank is spiked, upon which the masonry of first-class ashlar is laid in large blocks. The outside walls are usually carried up about 16 feet, at which height the bins are started. These walls are pierced at the required points by doors and windows. The intersections of the bins are supported by three heavy squared posts, forming piers, as it were, which posts are usually made from oak, beach, or elm, and are from 12 to 16 inches square. All these posts in each pier are in the same plane, one being vertical, the other two battering, like struts; the opposite struts of two adjoining corners have a heavy straining beam between them. Heavy parallel girders run across from wall to wall, resting at their intermediate points upon the piers and straining beam. Heavy cross joists run at right angles to these girders upon which the bins are started.

The sides of the bins are formed of plank laid flatwise, usually two inches thick and spiked, the spikes being long enough to reach

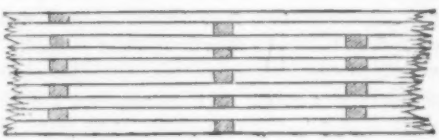
through two thicknesses of plank, and part way into a third. These bins are carried up to various heights, and, as before remarked, are usually 10 to 12 feet square. The lengths of planks are so arranged as to break joint with each other, the same plank often running through the distance of three and sometimes four bins. This arrangement frames all the bins together, and adds greatly to the stiffness in resisting the bulging tendency of the grain.

The accompanying Fig. 1 will better illustrate this construction, showing, as it does, a plan of two bins, with a portion of one side in elevation, (Fig. 2.) In the elevation are seen the planks laid together, and running through two or more compartments, breaking joint with each other.



The outside corners of bins constructed in this manner are further stiffened by clamps, and the outer sides resting immediately upon the walls forming the first story are made from wider plank. With the exception of the motive power itself, all the machinery for operating the elevator is located immediately upon the tops of the bins. There are at least two elevating "legs," as they are called, in any elevator, but they are multiplied according to the work to be performed and the size of the warehouse. These legs may be either "marine" or "house" legs. The marine leg is used to empty vessels, and is located in what is called a "tower," which is nothing more than a high projection from the main building. This tower has a free passage way under it, and is supported upon the extreme edge of the dock or pier by heavy square timber posts founded upon piles. The only entrance to the upper part of the building is through the tower, in which all the weighing is performed. Two strongly braced guides allow a vertical motion to this leg, while an outward motion is given to it by swinging it upon the axis of the head pulley, the slack in the driving belt that is caused by the varying position of the leg being taken up by means of tension pulleys, which will be described hereafter.

Fig. 2.



The "house leg," which is stationary inside the building, elevates the grain discharged by the marine leg into a hopper at its foot to the top of the house, where spouts distribute it to the various bins. These legs consist of two rectangular boxes of heavy plank connected at top and bottom, spread apart at the top in order to give sufficient room for the large "head pulley." An endless belt passes through these boxes and over a band wheel at either end.

At close intervals buckets, in form of quarter cylinders, are secured to this band, which dip up the grain as fast as it is fed to them. This is the simple construction of a steam elevator, but in the more modern built grain warehouses, it is usual to add conveniences for drying, cooling, and cleaning grain. Heretofore, much grain has been damaged by vessels encountering the sudden and heavy storms of the lakes, but now the perfect appliances of modern mechanical construction will save any cargo, no matter how wet it may be, if the vessel should make port in a reasonable time. Grain sometimes reaches the great entrepôt of Buffalo so mixed with chaff, sand, dust, and such like, the accumulation of hundreds of miles transportation by rail and water, that its value is very much impaired. Of course, an additional charge is made for both cleaning and drying grain thus injured, as its value is increased about twenty-five per cent. All these appliances will be described in connexion with the elevators to which they may be attached.

Before going into the details of elevator construction, let us take a glance at a few of the Buffalo and other lake port elevators, and, first of all, the

Sternberg Elevator.—This building is provided with fifty-six bins, 40 feet high, representing a storage capacity of 350,000 bushels of grain. The foundations for the outer wall consist of three hundred and sixty piles, driven three abreast, the minimum diameter of piles at top being 12 inches. Each pier or set of posts is supported upon nine piles. The outside walls are started on the piles 4 feet wide, and in courses of two feet thick. These walls are stepped off to a width of 2 feet 6 inches in a height of 6 feet. The wall is carried up of that width to the bottom of the bins, an elevation of 14 feet. This wall is undressed ashlar, laid in courses 2 feet 4 inches in thickness, every third stone being a header. The piers are built of large single stones resting upon the piles, the lowest stones being 4 feet square and 2 feet thick. These stones diminish in size in a height of 6 feet, to the capping stone, 12 inches thick, and 2½ feet by 3 feet. The heavy timbers that immediately support the bins are placed upon, and bear against, the capping stones. The above-described lower story is pierced by five doors and seven windows, the shutters for which are wrought iron. As before remarked, the bins are 40 feet high and 10 feet square, built of two-inch plank laid flatwise, and start from the coping of the outer walls, and the cross girders supported by the posts on each pier. The planking composing the outside walls is 9 inches wide half way up, and 8 inches the other half. The divisions of the bins are formed of plank, 7 inches wide one-third up, 6 inches one-third, and 5 inches the other third. All the planking is nailed together with spikes reaching through two thicknesses and one inch into the third. At all intersections or crossing of corners, there are three spikes driven as additional security. All outside corners are clamped by means of iron straps, one-half by 4 inches, hooked down at the ends and securely spiked. These clamps are put every 18 inches one-half the height of the bins. For convenience of getting down into the bins, each bin has

a ladder in one corner of round iron. The bottoms of the bins are hopper-shaped in two directions, and are supported upon joists 7 inches apart, except the two nearest the centre, which are 12 inches apart, to allow sufficient room for the discharge spout with its slide to regulate the flow of the grain. The flooring forming the bottoms of the bins is made in two courses of inch boards. On the top of the bins, a main run-way is laid, passing entirely through the centre of the building, from which smaller ones diverge, so as to reach the several bins. The operating engine is located in a small fire-proof building alongside the elevator warehouse, the brick smoke-stack being carried up beyond the highest point of the building. One bin space is left vacant in order to permit the main driving belt to be taken up to the band wheel situated on top of the bins. From this point the power is transmitted to the belts working the inside or house leg, and also the outside or marine leg. The whole building is made fire-proof on the exterior by means of a covering of corrugated iron. This warehouse has three sets of elevator legs—one to elevate from vessels, one to distribute, and one to discharge.

The New York Central or city elevator, (recently burned down,) was built of brick, the foundation being of the usual pile construction. It was divided into three compartments by brick walls, raised as high as the bins. These brick walls formed a fire-proof casing for the bins, as it were, which were composed of plank precisely as in the before-described Sternberg warehouse. The roof and framing of the upmost story rests upon the outside brick walls, and not, as in the case of the Sternberg, upon the bins themselves. The storage capacity of this building was 450,000 bushels, with a transfer capacity of 4000 bushels per hour. There were attached to this elevator seven sets of legs, of which one was used for raising grain from vessels, two for filling house, one to load cars, and three for emptying house.

The Reed Elevator, with a capacity of 200,000 bushels, was, at the time it was built, (1862,) considered the most complete elevator in all its appointments in Buffalo, and cost about $40,000. The first story is brick, resting upon piles, and the bins, 50 feet high, are made in the usual way of plank laid flatwise. This building is made externally fire-proof, by having the tower portion covered with corrugated iron, the sides and roofs being slated. In connexion with the Reed Elevator is a grain dryer, known as Marsh's patent. In general, the operation of this dryer is as follows: The damaged grain is elevated by the marine leg, and discharged through a spout in such a manner that it will spread over a metal surface perforated by very fine holes. The grain thus fed at one end is stirred and worked across the metal surface by means of a mechanical rake. Under that half of the surface which is towards the receiving end, a current of *hot* air is forced, and under the other half, a current of *cold* air, which cools the heated grain. It is then in a condition for storing, and is spouted into a receiving hopper in the interior of the building, the house leg raising it for distribution to the various bins.

This dryer has a drying surface of a little over 800 square feet, and will dry a maximum of five hundred bushels of wet grain per hour.

The small elevator of the Erie Railway Co., at Dunkirk, has a capacity of 24,000 bushels, and is situated in the middle of a pier jutting out into the harbor about 500 feet. The pier room on either side of this warehouse is shedded over for the reception of eastward and westward bound freights. The railway tracks run the whole length of the pier and through the elevator.

The method here employed to weigh grain is different from that in use at any of the other elevators. In addition to the arrangements in the tower for weighing the grain received, another is used to weigh the grain shipped in each car. This consists of a hopper, with scale attached, placed on a small truck, and is run under any bin that is to be emptied. As fast as a hopperful is weighed, it is spouted off into the car placed to receive it. This building is not protected against external fire, the bins and tower being merely sided up and down, and the cracks battened.

The Union Railroad Elevator, at Cleveland, differs considerably in its arrangements from any of those previously mentioned, inasmuch as it either receives from cars or boats, or distributes to cars or boats. The ground plan is 114 feet by 65 feet, with a boiler room of 33 by 35, built alongside. The cars are weighed in the building itself, on long platform scales.

The Michigan Central and North Indiana Railroad has three elevators at Toledo, with a total capacity of 1,250,000 bushels, but inadequacy of foundation will never allow of their being entirely filled. These warehouses elevate from cars alone, and transfer to boats by means of spouts.

By far the largest elevators yet built are those of Chicago, which, like those of Toledo, receive alone from cars, transferring to boats for eastern ports; among these the Sturgers & Buckingham is one of the finest. This building covers an area of 200 by 100 feet, and has a capacity to store 700,000 bushels of grain. The foundation consists of piles, protected around the whole periphery by a substantial cribbing. This elevator, like all others in Chicago, is cased with brick, slate not being in so much favor as a fire-proof protection. The Flint & Thomson elevator at this place, has a capacity of about 1,250,000 bushels, which is the largest grain warehouse ever constructed.

The accompanying plates represent a recently completed elevator, at Buffalo, called the "Richmond Elevator," and shows the whole internal working and arrangement of machinery.

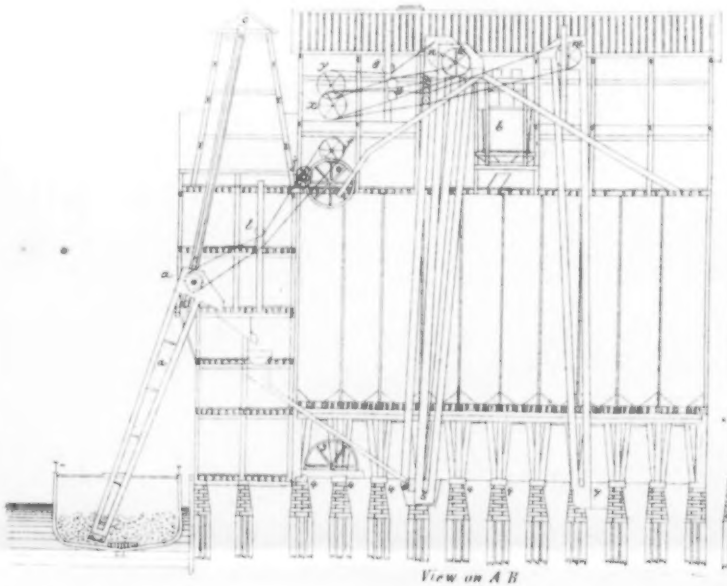
Plate I, Fig. 1, shows the location upon the dock, and also the plans of the foundations and bins. The boiler is in a small building adjoining the warehouse, the engine being inside the main building, on the first floor, as shown. There are seventy-two bins, the three interior elevator legs and belting from the fly-wheel shaft taking up the space of five bins. These bins are 50 feet high, and 10 feet from centre to centre.

Fig. 3 shows a plan of the spouting conducting the grain from the house legs to the several bins.

Fig. 2 shows, on the left side, a section through centre of building and tower, and on the right side an interior view, with the tower

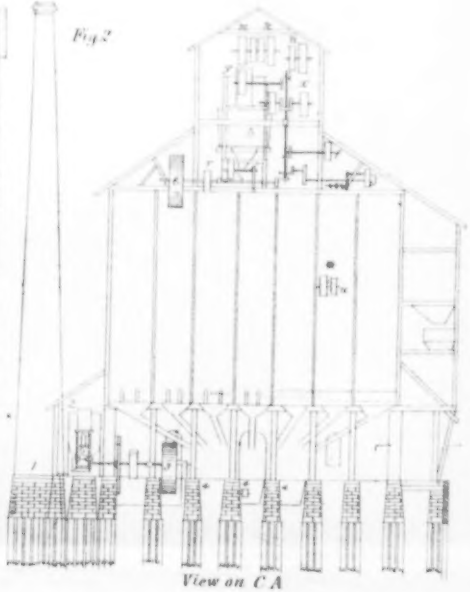
Foundation

Plan of Bins

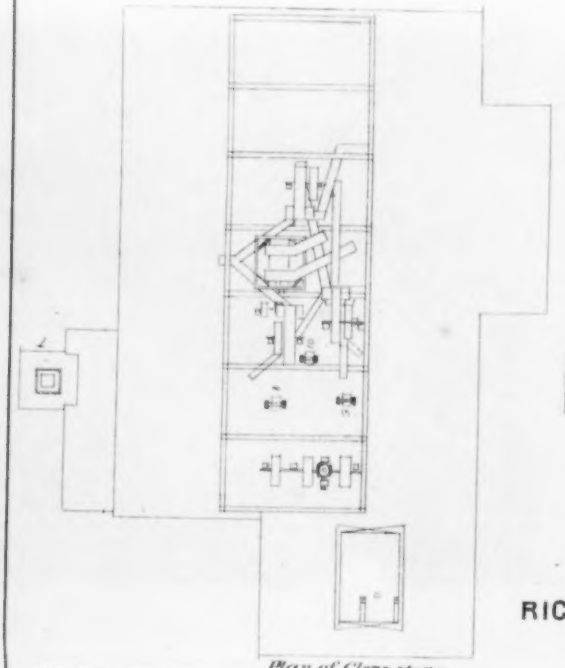


View on A B

Fig. 2

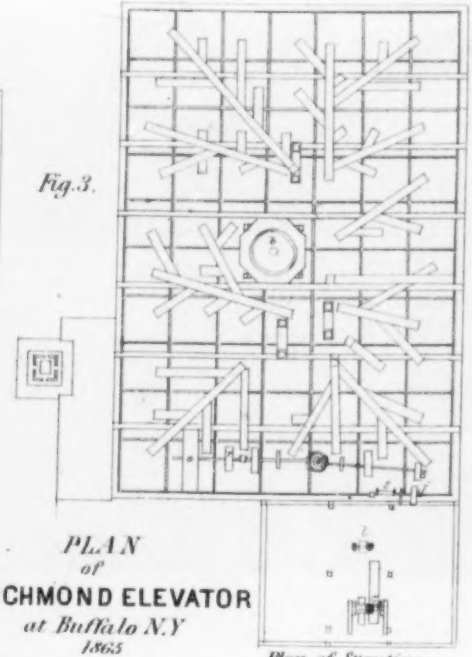


View on C A



Plan of Clere story

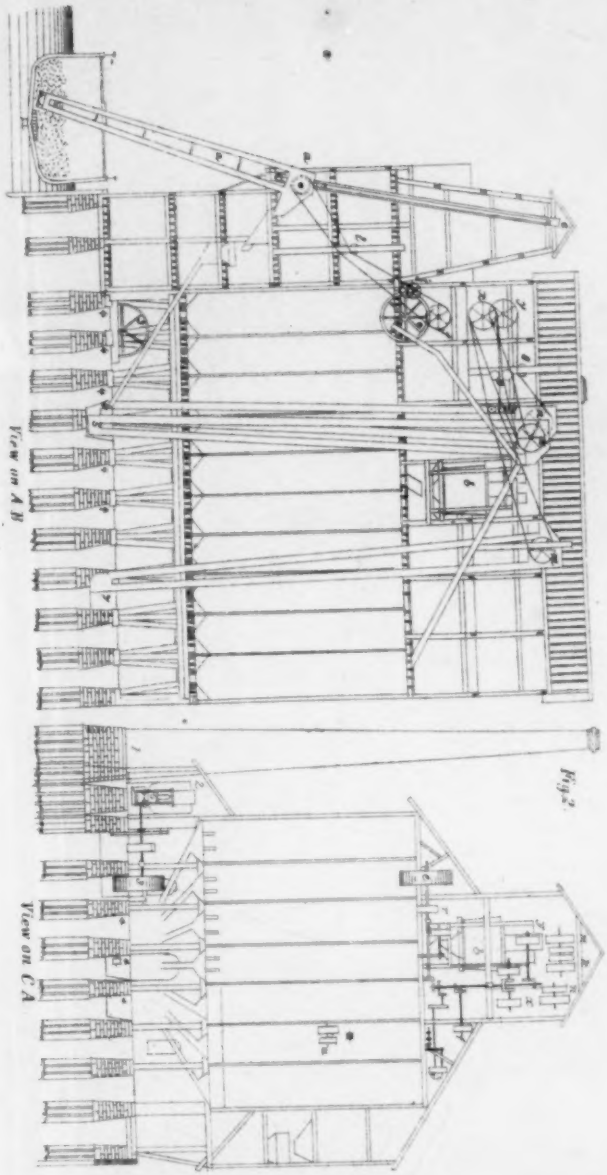
Fig. 3.

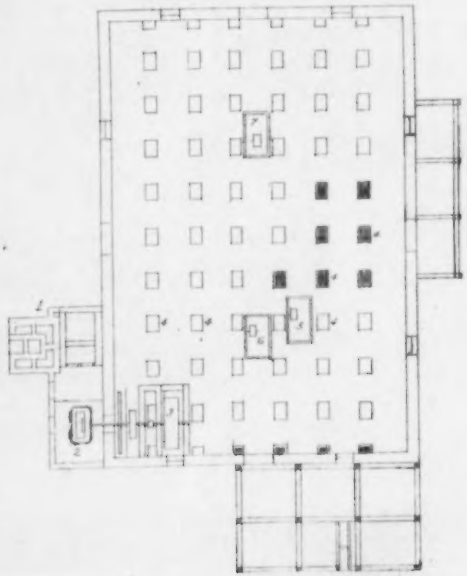


PLAN
of
RICHMOND ELEVATOR
at Buffalo N.Y
1865

Plan of Spouting

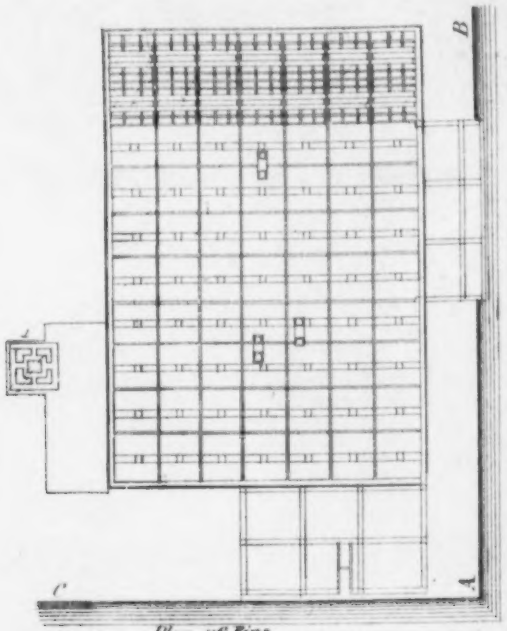
T
paci
out
this
west
the
T
use
in th
the
attac
empt
the
terna
the
Th
arran
either
groun
built
platfo
Th
tors a
quacy
wareh
of spo
By
like t
easter
the fin
a capa
of pile
bing.
slate n
& Thor
bushels
The
at Buff
ternal
Plat
of the
ing the
first flo
vator l
five bin
Fig.
house l
Fig.
and to





Foundation

Fig. 1.

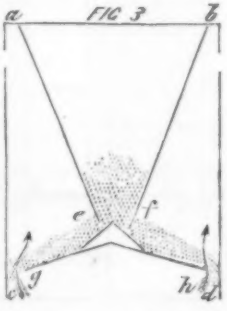


portion removed. A vessel is represented alongside of the dock being unloaded, the marine-leg having been lowered into its position by means of the block and tackle, which is seen running up to the top of the tower. The slack, which would otherwise be in the band that drives the head pulley in the marine leg, is taken up by the tension pulleys, as shown at Fig. 2. These tension pulleys are nothing more than small band wheels, revolving in a frame, which frame slides up and down between two guide posts. This frame is weighted sufficiently to always bear down upon the driving belt, no matter what the position of the marine leg, and thus produces a proper amount of friction for the belt to accomplish its purpose. The weighing hopper is shown in the tower, also the spout, directing the grain, when weighed, to the foot of one of the house legs, which elevate it to the top of the building for distribution.

The interior view, on the right of the plate, shows the construction at that part of the building where the grain is merely transferred to boats. It is fitted up with a receiving and weighing hopper, the former being filled by a spout from one of the house legs. When it is desired to transfer grain that is in store, it is necessary to discharge from the bins that are to be emptied into one of the hoppers that a house leg connects with, and then elevate to the top of the building, and spout into the receiving hopper of the transfer portion. [The various portions of the machinery, &c., in so far as is necessary to identify them, are marked the same upon all the plates.] This elevator was built by Mr. George Clark, of Buffalo, and has in connexion with it very perfect arrangements for cleaning, drying, and cooling grain, all of which were designed by Mr. Clark, and they are as perfect in their operation as is possible to conceive of. The *cleaner* is shown upon the preceding plates, marked *b*, situated about the centre of the building, and above the bins.

The whole apparatus is enclosed in a large wooden cylinder, of which the figure represents a section through the center. The accompanying cut, Fig. 3, will show the principle of its construction. *a b c d* represents a vertical section of the cylinder, having a hopper, *a b e f*, constructed within it. The grain to be cleaned is spouted from one of the house legs, directly into this hopper. Below the mouth of hopper, as shown, is a small flattened cone, which is so attached as to regulate, automatically, the amount of uncleaned grain fed to the spreading cone *g h*. Upon the top of the cylinder, and on either side, are two fan-blowers, which suck the dust and chaff up in the direction of the arrows, the grain thus winnowed dropping into the spouts beneath, which direct it to the proper bin for storage. The chaff is carried off by spouts attached to the sides of the cylinder, to what may be called a waste bin.

FIG. 3



The *dryer* and *cooler* is in a separate building adjoining the eleva-

tor, of which the subjoined cut, Fig. 4, represents the foundation, in which *a* is the furnace room; *b*, smoke stack; *c c c*, flues; *j*, drying kiln; *h*, hot air pressure chamber; *i*, hot air exhaust chamber; *g*, machinery room; *e* and *e'* are cool air chambers; *d* is the cooler.

FIG 4

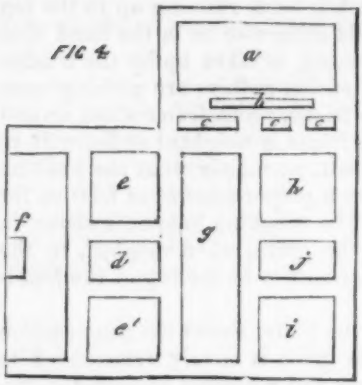


Fig. 5 shows an end elevation, in which C D is the drying bin; *a b* is an elevator leg to convey dried grain to cooler; the arrows indicate the operation. The grain is spouted into the top of the dryer from one of the house legs. This dryer is a fire-proof box, as it were, filled with inverted triangular troughs of perforated sheet iron, among which the wetted grain gradually works its way by its own weight. These troughs are sealed up at alternate ends, so that the hot air forced into the dryer through the troughs can only find vent through

FIG 5

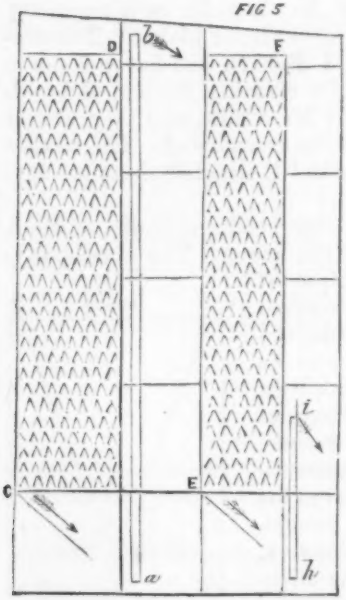
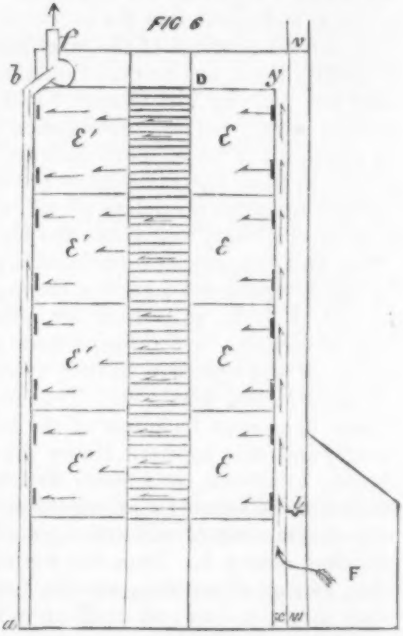


FIG 6



the perforations, and thus insures the whole of the grain becoming thoroughly dried. A spout directs the dried grain to the foot of the elevator leg *a*, when it is again elevated and discharged into the cooler F E, where it goes through a similar process, only being supplied with a cold blast

instead of a hot one, and is directed to the base of the elevator leg *h*, and elevated to a sufficient height to be spouted into the main building, when the house legs elevate it finally for stowing. This is the general idea of the process, but the exact method may be perhaps understood by referring to Fig. 6. F is the furnace room; *w v* is the chimney from which the heat may be directed into the heater *x y*, by means of the damper at *l*; E E, &c., fire-proof hot air chambers, the outside walls of brick, the inner partitions of cast iron; C D is the drying kiln, corresponding to C D in Fig. 5, filled with the triangular troughs, troughs closed at one end; an open and a closed end are made to alternate with each other, so that the heat may be retained as long as possible before passing off; E′ E′, &c., are the hot air exhaust chambers shown in Fig. 4; *a b* is an exhaust flue, the draught being made by the suction fan at *f*.

In the hot air flue *x y* are registers, shown by the arrows; arrows also show the passage of the hot air from the furnace through the grain, and out through the exhaust flue. The cooling part of the operation is exactly similar, the cold air being sucked by fans through apertures in the walls, which apertures take the place of the registers of the hot air flues. The quantity of hot air admitted is ingeniously arranged by an automatic contrivance depending upon the contraction and elongation of an iron lever connected with the registers. This bar, in its contraction and expansion, opens or closes the registers, and thus admits a perfectly equable current of hot air. The whole arrangement reflects a great credit upon its inventor, Mr. Clark.

This dryer and cooler will dry and cool four thousand bushels of wet corn per hour, or two thousand bushels of new corn. It has a heating surface of sixteen thousand square feet, a strong contrast to the Marsh dryer, which has a little over eight hundred square feet. The price for drying and cooling new corn was, in 1864, four cents per bushel, and for wet corn, one and three-quarter cents, which were very remunerative rates at that time. The cost of this addition, all complete, to the Richmond Elevator, was thirty thousand dollars. During the same season, 1864, the price for elevating grain at Buffalo, was one and one-half cents per bushel, and one and three-quarter cents for storage after the first five days.

(To be continued.)

For the Journal of the Franklin Institute.

Anchors and Chains of Sail and Steam Vessels.— Their weight, dimensions, and length. By Chas. H. Haswell, Engineer, New York, U. S.

Read before the Institution of Naval Architects, London, March 23, 1866.

Within a comparatively brief period the chain cable has been introduced in marine navigation *in lieu* of the hemp cable long in use antecedent thereto, and scarcely had their relative merits and capacities been developed, before two novel elements in marine navigation, affecting the weights and dimensions of both anchors and chains, have been presented, in clipper ships and steam vessels.

In England, the regulations and the requirements of the underwriters are such as very satisfactorily to provide for the proper equipment and fitting of a vessel in her requirements of "ground tackle," as it is termed, so far as her security at anchor is concerned.

The question, however, very naturally arises, Upon what deductions are these regulations based? Are they unnecessarily onerous in some points, and insufficiently provident in others? Are the varying elements of full-modeled and clipper builds, full and light-rigged vessels, or sea and river steam vessels, fully considered? If not, the requirements for safety, the economy of cost of equipment, the unnecessary burthening of a vessel, are all involved in these questions, and, in my opinion, each are of sufficient interest to justify an invitation of the attention of this body to the subject submitted.

In the merchant service of this country there are but few restrictions put upon the character and extent of either the equipment or fitting of a vessel, the matter being controlled by the builder or owner of the vessel, under the guidance of their knowledge, or views of their interest, on the one hand, and by the opinion of the underwriters upon the other.

In the naval service, however, rules for the determination of the weights of anchors, and the diameters of their chains, have been adopted, together with regulations as to the number of anchors and kedges and the lengths of cables.

The basis of the rule for the weight of anchors is the width of beam of a vessel squared, to which is assigned a unit, expressing the relative resistance of differing rates of vessels, in several classes, in their spars and rigging, and as the element of tonnage, under the old and now happily repealed United States law, is used as expressing the volume of a vessel, the rule is complicated, and as the units given are confined to naval vessels alone, the rule is too partial for general utility. I purpose, therefore, to submit to your consideration a rule, similarly based, for vessels of the merchant service, introducing the length of a vessel *in lieu* of tonnage computation, under an abrogated law, and thus rendering the application of it more *facile*, added to which, under existing rules of underwriters, and the various tables of weights of anchors, chains, &c., &c., published by the makers and venders of them, their weight is based upon the tonnage of a vessel without any reference to existing differences in model or rig, and, as the computations for tonnage vary in different countries, the rule is partial in the cases to which it applies, and restricted in its operation, without the intervention of the necessary reduction by computation.

As regards the propriety of tonnage or *volume* of hulls, in any manner being made the sole basis of assignment of the weight of an anchor, &c., I submit the following instances in illustration of its impracticability, viz: A full-built and full-rigged sailing vessel; a full-rigged clipper; a full or light-rigged side-wheel or propeller steamer; and a three masted schooner, all of which, if being of like tonnage, would have differing requirements of anchors and chains, and yet, under the general rule based upon tonnage, they would be fitted with

anchors of like weights, unless the differences should be estimated by the individual controlling the matter, in accordance with his particular views or interest, and, of course, subjected to the accident of his ability or truthfulness to discharge the duty.

As regards steamers, the general rule adopted, even by the regulations of Lloyd's, is that of assigning the weight of anchors at two-thirds that of a sailing vessel of like tonnage, without any reference to their being side-wheels or propellers, or to the character or extent of their rig.

In the following table the varying elements of construction, rig, and volume are considered, and an unit of computation assigned for each:

TABLE *whereby to determine the Weight of the Anchors, (exclusive of their stocks,) and also the number of anchors and kedges and lengths of chains for a vessel of a given class and rate.*

CLASS OF VESSELS.	Multipliers.	Number assigned.			L'gth of chains in fathoms.	
		Bowers.	Stream.	Kedges.	Bowers.	Stream.
SAILING.						
Ship, full built, length exceeding 180 feet.	3·	3	2	2	300	105
" " " 150	2 9	3	1	2	300	90
" " " 120	2 75	3	1	2	270	90
" half clipper, " 180	2·8	3	2	2	300	105
" " " 155	2·7	3	1	2	300	90
" " " 130	2·6	3	1	2	270	90
" clipper, " 220	2·8	3	2	2	300	105
" " " 185	2·7	3	1	2	300	90
" " " 150	2·6	3	1	2	270	90
Bark, full built, " 130	2·75	3	1	2	270	90
" " " 110	2·6	3	1	2	210	75
" " " 90	2 4	3	1	2	210	75
" half clipper, " 130	2·65	3	1	2	270	90
" " " 100	2·35	3	1	2	210	75
" clipper, " 140	2·6	3	1	2	270	90
" " " 110	2·35	3	1	2	240	75
Brig or brigantine, full built, " 100	2·4	3	1	2	240	75
" " " 75	2·3	3	1	2	210	75
" half clipper, " 110	2 2	3	1	2	240	75
" " " 85	2·1	3	1	2	210	75
" clipper, " 120	2·2	3	1	2	240	75
" " " 90	2·	3	1	2	210	75
Schooner or sloop, full built, " 125	2·	3	1	2	240	75
" " " 100	1·8	3	1	2	210	75
" " " 75	1·5	2	1	1	180	60
" " " 50	1·25	2	1	1	150	60
" half clipper, " 125	1 8	3	1	2	240	75
" " " 100	1·6	3	1	2	210	75
" " " 75	1·4	2	1	1	180	60
" " " 50	1·2	2	1	1	135	60
" clipper, " 140	1·75	3	1	2	240	75
" " " 110	1·5	3	1	2	210	75
" " " 80	1·25	2	1	1	180	60
" " " 50	1·15	2	1	1	135	60
Boats.....	1·2	1	...	...	25	...

TABLE, (*continued.*)

STEAMERS.							
Propeller, ship or bark, l'th exc'd'g, 325 feet.	2·8 / 2·6	3	1	2	300	105
" " " 300	2·75 / 2·55	3	1	2	300	105
" " " 275	2·7 / 2·5	3	1	2	300	105
" " " 250	2·6 / 2·4	3	1	2	300	105
" brig, " 250	2·5 / 2·3	3	1	2	300	105
" " " 200	2·35 / 2·2	3	1	2	270	90
" brigantine, " 225	2·25 / 2·05	3	1	2	270	90
" " " 175	2·1 / 1·9	3	1	2	270	90
" schooner, " 225	1·9 / 1·7	3	1	2	240	75
" " " 175	1·7 / 1·5	2	1	2	210	75
" " " 125	1·5 / 1·3	2	1	1	180	60
" tug boats, " 125	1·3 / 1·1	2	1	1	180	60
" " " 75	1·2 / 1·	1	1	1	120	45
" without any rig, with upper deck cabins fore and aft.....	2·1 / 1·9	2	1	1	180 / 120	60 / 45
" with deck cabins only.....	1·8 / 1·6	2	1	1	120 / 105	60 / 45
Sidewh'ls, ship or bark, l'gth exc'dg 300	2·8 / 2·6	3	1	2	300	105
" " " 275	2·75 / 2·55	3	1	2	300	105
" " " 250	2·62 / 2·4	3	1	2	300	105
" brig, " 250	2·55 / 2·35	3	1	2	300	105
" " " 200	2·4 / 2·2	3	1	2	270	90
" brigantine, " 225	2·3 / 2·1	3	1	2	270	90
" " " 175	2·15 / 2·	3	1	2	270	90
" schooner, " 225	1·95 / 1·75	3	1	2	240	75
" " " 175	1·75 / 1·55	2	1	2	210	75
" " " 125	1·55 / 1·3	2	1	1	180	60
" tug boats, " 125	1·45 / 1·25	2	1	1	180	60
" " " 75	1·35 / 1·15	1	1	1	120	45
" without any rig, with upper deck cabins.....	2·3 / 2·	2	1	1	180 / 120	60 / 45
" with deck cabins only.....	2· / 1·8	2	1	1	120 / 105	45 / 45

Bower anchors should be alike in weight. For the convenience, however, of light-handed crews, it is customary to make a very material difference between them, which is a very grave error; for if the best or heaviest should foul, or be lost, the second, or "working anchor," as it is termed, is altogether insufficient to hold the vessel when more than ordinary security is required.

If, however, the rule of like weights is departed from, it should not exceed the proportion of 10 per cent. added to the standard weight for the best bower, and a like deduction from the standard for the second best bower.

The weights of all anchors and kedges are given exclusive of the weights of the stocks.

The weight of a stock is about one-fourth of that of its attached anchor.

Stream anchors should be one-fourth the weight of the bower.

Kedges, when two are used, should be one-sixth and one-tenth the weight of the bower, and when one is used, one-eighth of that weight.

The application of the preceding table is as follows:

Multiply the square of the extreme breadth of the vessel by the unit given in the column of multipliers, and the product will give the weight of the anchor in pounds.

To determine the diameter of a chain cable corresponding to an anchor of a given weight, cut off the two right-hand figures of the number expressing the anchor's weight in pounds, and multiply the square root of the remainder by 4, deduct 3 from the result when the anchor's weight is of and over 8000 lbs., 2 when it is between 7000 and 8000, and 1 when it is of 7000 or more than 4000, and it will give the diameter of chain in *sixteenths* of inches.

For the Journal of the Franklin Institute.

Cambered Bridge vs. *The Arch.*

By De Volson Wood, Prof. C. E., University of Michigan.

In the last May number of the *Journal*, page 291, I find the following remark: "When camber is properly constructed in a bridge, the bottom chords are not strained by tension, until the deflection of the truss is so great as to pass the horizontal chord line. *Until* then the whole truss acts like a flat arch, and consequently, when the camber is considerable, no deduction for loss of strength by area cut away need be provided for, as would be necessary for a straight beam, when deflection to the slightest amount would call upon the bottom chord to resist tension."

If I correctly understand the writer in the above statement, I think it involves an erroneous principle. The idea seems to be, that in a flat arch there is no tendency to tension on the lower side. It is true, when the arch is composed of disconnected parts, as voussoirs, it resists only compressive strains, but in this case, the thrust of the arch must be resisted by a force at the abutment. This force may be the

pressure of the abutment, or of the earth, or friction on the abutment, or a horizontal tie, or by some of these combined. But in the cambered bridge—the case discussed by the writer—the truss simply *rests* on the abutments. For such a case, whether it be a cambered bridge, a trussed arch, a curved beam, or a roof shaped truss, when acted on by vertical forces only, I venture the broad statement that, *when the upper part is compressed, the lower part is* EXTENDED.

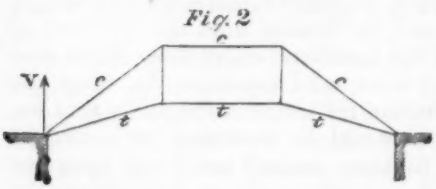
I will not at this time enter into an analysis, but will make a few statements, the truths of which are so evident that I trust they will carry conviction.

If an arch could be so loaded that it would be a curve of equilibrium, *i. e.*, so that the resultant of the forces at any point would be in the direction of the tangent to the intrados at that point, and the same curve be vertical at the abutments, then there would be only compressive strains; such might be the case with normally pressed arcs, or so made by some peculiar law of loading. It is, however, more ideal than real.

Fig. 1

If the arch be parabolic and uniformly loaded over the span, it will be a curve of equilibrium. But as it is not vertical at the abutment, it will tend to slip outward. If T be the thrust at the abutment *i* the angle which the tangent to the curve makes with the horizontal, and H the horizontal component of the thrust, we have $H = T \cos. i$, which must be resisted by a tie or friction, or some other force. If there be no extraneous force, then, when it slides out, the crown will be depressed, and tend to break by being compressed on the upper side *and extended on the lower.*

Fig. 2



Take the simple case shown in Fig. 2. If the lower end pieces are subjected to tension, then must the lower middle one also be subjected to tension. No bridge builder would venture to cut away any of the lower timbers in this case.

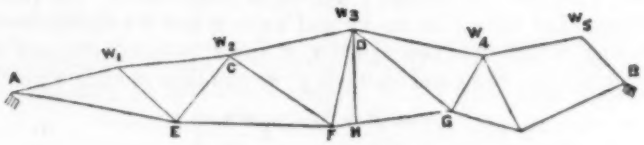
I trust that these examples are sufficient to illustrate the correct principles.

Formulas for Obtaining the Strains on the several parts of Girders and Roofs. By ALFRED A. LANGLEY, C. E.

From the Civil Engineer and Arch. Journal, May, 1866.

Let any triangular combination of bars, such as is shown in the annexed figure, be loaded with weights w_1, w_2, w_3, &c., at the point of junction of the intermediate and upper bars. Find the weight or reaction at the support A owing to these weights, which call R. Let S equal the strain on any of the lower bars in the direction of its

Fig. 1.



length, which strain we shall now proceed to find on the bar FG. Draw the line HD perpendicular to FG, and through the point D. Let the sum of the weights between D and the support A be called W, and let the horizontal distance of its centre of gravity from D be called g, also let d equal the horizontal distance between A and D. Then taking the moments about the point D, we have—

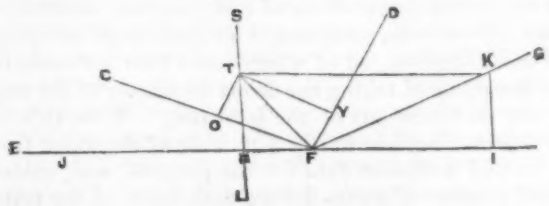
$$S = R\frac{d}{D\,H} - W\frac{g}{D\,H}.$$

By the above process the strains on each of the lower and upper bars may be obtained; the upper bars will be in compression, and the lower ones will be subject to a tensile strain.

Intermediate Bars.—There are four bars meeting at each side of the points E,F,G, &c., their directions are known, and after obtaining the strains on the two lower bars by the preceding formula, the forces acting on the remaining two intermediate bars can be calculated by properly resolving the forces so that they may be in equilibrium.

The forces can readily be arrived at by construction as follows: Let the inclination of the four bars meeting in F be shown in Fig. 2

Fig. 2.



by the lines EF, CF, DF, and GF. On the lower bars set off distances, FJ and FK, representing the strains on these bars. Produce the line of

the bar on which there is the greatest strain, which we will suppose to be JF. Draw a line from K perpendicular to EF, and intersecting it in I. Set off JN = FI. Draw LS through the point N, perpendicular to JF, and draw a line parallel to EI from K, intersecting LS in T; then will TF be the resultant of the forces acting on the intermediate bars. From T draw lines parallel to FD and FC, intersecting them in O and V; then will FO and FV represent the strains on FC and FD, respectively. When T lies between the intermediate bars, they will both be in compression, and, when between the lines of the intermediate bars produced below F, both in tension; but if the resultant is not in either position, then the bar nearest T will be in compression, and the other in tension. Let the strain on EF and FK = H and h respectively; also let the angles CFE, CFD, and DFG = a, β, and φ, respectively, and the required strain on CF = x and on DF = y; we can then at once write down.

$$x = \pm \text{H} \frac{\sin.(a+\beta)}{\sin.\beta} \pm h \frac{\sin.\varphi}{\sin.\beta}$$

$$y = \pm h \frac{\sin.(\varphi+\beta)}{\sin.\beta} \pm \text{H} \frac{\sin.a}{\sin.\beta}.$$

For the Journal of the Franklin Institute.

Comparison of the Actual and Effective Area of Exhaust Openings.

By FRED. J. SLADE.

In investigating physical phenomena, by means of mathematics, or in making deductions from laws already determined, it is unsafe to proceed far without checking and verifying our results by direct appeal to experiment. This is the more essential as in the majority of cases a variety of causes are in operation at the same time, mutually modifying their effects.

Thus, in regard to the subject before us, it is easy when we know the area of an exhaust opening and the time during which it exists, to calculate the quantity of steam that will be discharged, and ascertain the resulting back pressure against the piston, if we suppose the steam simply to obey the law of velocity of fluids under a difference of pressure, and the cylinder to contain only its own volume of steam. But when we consider the effects of leaky valves, water remaining in the cylinder either to be evaporated or carried off as spray, and the friction of crooked pipes, all of which exert their influence in practice, we see the necessity of taking the direct testimony of the engine itself, which we can do by means of the indicator. With this object, the writer has selected promiscuously a number of diagrams from engines of which he had sufficient data for the purpose, and, calculating the theoretical discharge of steam during each tenth of the return stroke, will show how it compares with the apparent actual discharge as represented on the diagram. The method of calculation is simply as follows:

Let C = contents of space from the piston to the end of cylinder in cubic feet.

C_x = contents of space from the piston to the end of cylinder in cubic feet, after the former has moved through a distance x.

P = pressure above a vacuum in space C.

P_x = " " " " C_x.

(1.) Then $\frac{C\,P - C_x\,P_x}{\frac{P + P_x}{2}}$ = *apparent* actual discharge of steam in cubic feet at the mean pressure $\frac{P + P_x}{2}$.

Let A = smallest area of exhaust opening in square feet.

t_x = time, in seconds, occupied by the piston in reducing the contents of the cylinder from C to C_x.

p = external pressure in condenser or atmosphere.

c = cubic feet of steam of pressure $\frac{P + P_x}{2}$ equal to one pound.

(2.) Then $\sqrt{c\left(\frac{P + P_x}{2} - p\right)} \times 96 \times t_x \,.\, A$ = theoretical discharge of steam in time t_x, and (1) divided by (2) gives the relation between the actual area A, and the effective area under all modifying circumstances, which we will denote by R.

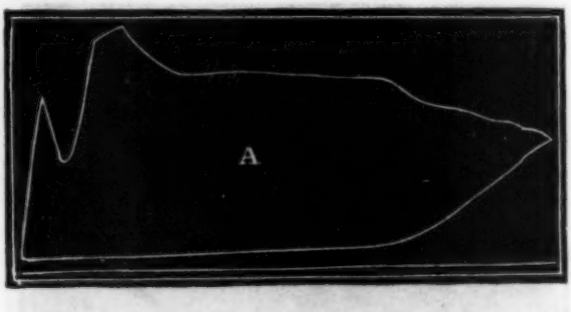


Diagram A is from a high pressure engine of 12 inches by 18 inches cylinder taking steam at 43 lbs. pressure during the whole stroke, making 95 revolutions and exhausting through 11 feet of 3 inch pipe and 5 elbows into a feed-water heater, thence through 32 feet of 3 inch pipe and 4 elbows into a large tank of about 150 times the capacity of the cylinder, and emerging from this near where it enters at the top through 100 feet more of 3 inch pipe and 14 elbows into the atmosphere. This is a case of considerable resistance from the tortuous line of exhaust piping, though it must have been somewhat relieved by the large tank acting as a temporary reservoir for the steam. The steam was quite wet, and, moreover, the exhaust pipe itself was the smallest part of the exhaust passage.

The results for this engine were as follows:

Tenths of stroke.	Area, square inches.	Time, t_x.	Apparent actual discharge, cubic feet.	R
1	3·80	·070	·387	·16
2	7·07	·032	·315	·18
3	7·07	·027	·217	·18
4	7·07	·021	·156	·18
5	7·07	·021	·125	·16
6	7·07	·021	·118	·16
7	7·07	·021	·130	·17
8	7·07	·022	·122	·17
9	7·07	·027	·119	·14
10	4·60	·062	·120	.10
Average				·16

The back pressure in the cylinder represents an apparent discharge of only ·16, that theoretically due to the area of opening. We say *apparent* discharge because the quantity of steam actually delivered must be greater from the causes before alluded to, but it is this apparent discharge that is of value practically as determining the amount of resistance to the piston.

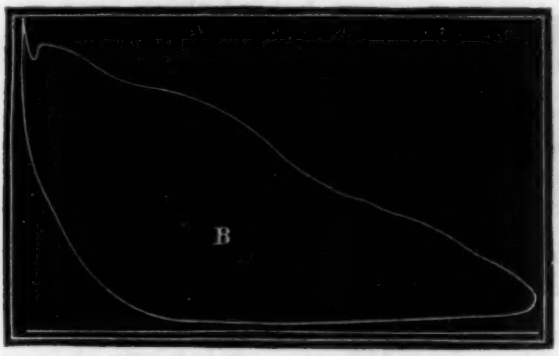


Diagram B was taken from locomotive No. 204, Erie Railway. Incidentally, we may remark, that locomotive diagrams are interesting from their rarity, and, indeed, it is believed that the series, of which this is one, taken by the writer, assisted by Mr. Phineas Barnes, Jr., in the summer of 1864, were the first ever obtained from a locomotive in this country.

In a locomotive we should expect better relative efficiency of exhaust area, since the whole of the passage is considerably larger than the one smallest part—the blast orifice—the exhaust pipe is very short

and the steam generally tolerably dry. The cylinders of this engine were "inside," and, therefore, kept warm by the smoke-box. The diameter of exhaust nozzle was $3\frac{1}{4}$ inches; steam ports, $15\frac{1}{2}$ inches by $1\frac{3}{4}$ inch; exhaust port, $15\frac{1}{2}$ inches by $2\frac{3}{4}$ inches; cylinder, 18 inches by 20 inches. At the time this card was taken the engine was making 160 revolutions per minute.

The results were as follows:

Inches of stroke.	Area of opening, square inches.	Time, t_x.	Apparent actual disch'ge, cubic feet.	R
$17\frac{3}{4}$ — $19\frac{1}{2}$	4·14	·033	·51	·35
$19\frac{1}{2}$ — 20	8·3	·019	·731	·51
20 — 18	8·3	·043	1·04	·40
18 — 16	8·3	·019	·338	·37
16 — 14	8·3	·015	·322	·45
14 — 12	8·3	·013	·269	·43
12 — 10	8·3	·0124	·312	·52
10 — 8	7·6	·0124	·294	·54
8 — 6	4·8	·013	·202	·52
6 — 5	1·7	·007	·025	·35
Average				·444

It will be noticed that the efficiency of opening increases toward the end of the stroke which may, perhaps, be best accounted for by the supposition that the evaporation and discharge of water from the cylinder reduces the apparent discharge at the first part of the stroke, though the actual discharge may be as large as at any other period.

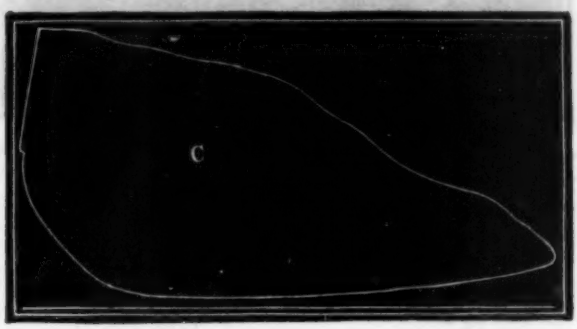


Diagram C is from engine No. 203, Erie Railway, the dimensions of which are: Cylinders, (inside,) 18 inches by 20 inches; steam ports, $15\frac{1}{2}$ inches by $1\frac{3}{8}$ inch; exhaust ports, $15\frac{1}{2}$ inches by $2\frac{3}{4}$ inches; exhaust nozzle, $2\frac{1}{8}$ inches diameter. The card was taken at a time when the engine was developing the large amount of 519 horse power, making 144 revolutions per minute; and we accordingly find a high back pressure against the piston, averaging, exclusive of compression, 10·5 lbs. above the atmosphere.

The efficiency of the exhaust opening was as follows:

Inches of stroke.	Area of opening, sq. inches.	Time, t_x.	Apparent actual discharge, cubic feet.	R
17·85 — 19·4	3·24	·025	·63	·564
19·4 — 20	6·49	·0255	·57	·32
20 — 18	6·49	·048	1·17	·38
18 — 16	6·49	·0206	·495	·415
16 — 14	6·49	·0165	·456	·50
14 — 12	6·49	·0143	·353	·46
12 — 10	6·49	·0136	·324	·46
10 — 8	6·49	·0136	·332	·475
8 — 6	4·75	·0143	·294	·56
Average.....				·46

The results in this case differ but little from those from the preceding diagram.

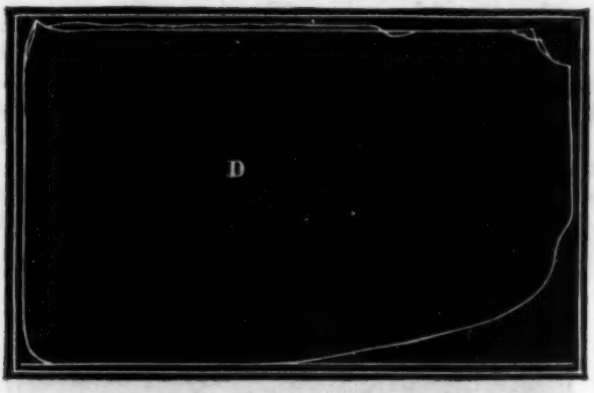
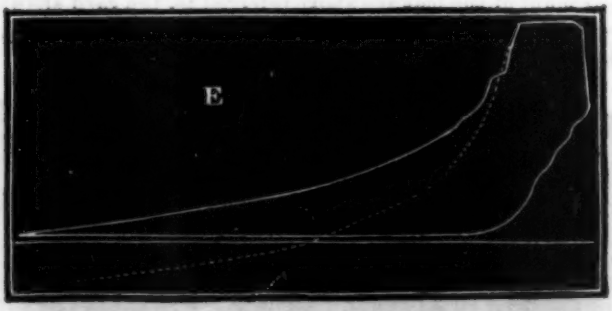


Diagram D, from engine No. 204, taken when the engine was starting its train, shows the rate of discharge of a large volume of steam at a moderate speed. In this case we have—

Inches of stroke.	Area of opening, sq. inches.	Time, t_x.	Apparent actual discharge, cubic feet.	R
20 — 18		·0783	2·56	·346
18 — 16	8·3	·0339	1·06	·415
16 — 14	8·3	·0273	·72	·48
14 — 12	8·3	·0235	·516	·44
12 — 10	8·3	·0225	·510	·59
10 — 8	8·3	·0225	·389	·88
Average.....				·517

As the pressure in the last portion of the stroke calculated falls very near the atmosphere, the determination of κ may be less accurate, as the least variation in measuring the diagram will make a considerable difference in its value. It will be observed that the value is unusually high. It should be borne in mind, however, that just at this time the other cylinder discharges its steam at a high pressure through a nozzle placed close beside the one through which this is exhausting, and this, acting as a steam jet, must tend to accelerate the flow of steam from the cylinder. When, as is sometimes the case, both cylinders exhaust through one nozzle, the discharge from one cylinder causes a considerable rise of back pressure in the other, amounting, when following full stroke, with the ordinary pressure of steam, to about 16 lbs. at the first opening of the opposite exhaust. For more ordinary points of cut-off, the back pressure is increased one or two pounds for about half the stroke.



Card E is from a stationary engine of novel but excellent construction. At the time of taking this diagram, however, the steam valve was leaking to an extent shown by the difference between the actual and theoretical lines, (the latter dotted,) which will account for the comparatively low value of κ, since, as the exhaust pipe was short, straight, and larger than the greatest area of port, we should expect a good proportion of discharge per unit of area. The steam leaking into the cylinder during the exhaust would make the discharge appear smaller than it really was.

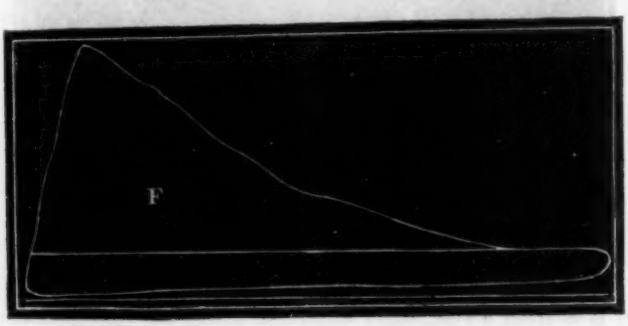
This, however, is a common case in practice, and on that account we give it a place.

The dimensions of the engine were: Cylinder, 26 inches by 30$\frac{1}{8}$ inches; exhaust port, 24 inches by 1$\frac{1}{2}$ inch. The amount of its opening, at each part of the stroke, which was the smallest part of the passage, is given in the table. Exhaust pipe, 33 feet long 7 inches diameter, with two elbows, both near the engine to conduct the steam into a feed heater, the remainder of the pipe being vertical.

At 48 revolutions the results were:

Inches of stroke.	Area of opening, sq inches.	Time, t_1.	Apparent actual discharge, cubic feet.	R
30 — 27	17·	·116	1·36	·20
27 — 24	28·	·052	·89	·205
24 — 21	31·5	1·345	2·8	·225
21 — 18				
18 — 15				
15 — 12	22·	·0444	·91	·33
12 — 9	15·75	·0444	1·03	·57
9 — 6	9·	·049	·78	·66
6 — 3	3·	·057	·46	·54
Average				·353

The exhaust port opened at 1¼ inch before the end of the stroke, yet, on account of the leakage above referred to, the card shows nearly 2 per cent. more steam in the cylinder, at the end of the stroke, than at the time of opening of the valve.



Card F is from a low pressure stationary engine of 10 inches by 20 inches cylinder. The least opening was at the valve, the port being but 4·25 inches by ·68 inch = 2·89 square inches. The exhaust pipe was 2½ inches diameter = 4·9 square inches area, 21 feet long, with four elbows. The valves were about as tight as usual in practice.

The line drawn below the diagram shows the vacuum in the condenser which was about 17½ inches.

Another diagram taken from the same engine, exhausting into the atmosphere, through a pipe about twice as long, shows for R a higher value, viz: about 21½.

The values obtained from the above diagrams will probably be lower than most persons would have anticipated. They are, however, no doubt, fair examples of ordinary practice, and are of interest on that account. They show clearly the importance of a short and free escape for the steam, and to many will be significant in relation to the water

condensed in the cylinder during the steam stroke to be discharged during the exhaust.

At 60 revolutions the results were:

Inches of stroke.	Area of opening, sq. inches.	Time t_x.	Apparent actual discharge, cubic feet.	R
19 — 20	·786	·0764	·074	·13
20 — 18	2·51	·116	·442	·18
18 — 16	2·89	·0485	·11	·12
16 — 14	2·89	·038	·10	·135
14 — 12	2·89	·0345	·099	·15
12 — 10	2 89	·033	·097	·158
10 — 8	2 89	·031	·108	·19
8 — 6	2·89	·032	·096	·17
6 — 4	2·88	·037	·106	·18
4 — 2	2·46	·041	·108	·23
2 — 0	1·62	·097	·073	·089
Average.....				·158

Dry Dock Iron Works, New York.

Portland Cement. By M. LEBLANC.

From the London Civil Engineer and Architect's Journal, May, 1866.

Having been charged, since the commencement of the year 1860, with the construction of the floating basin of the port of Boulogne, we have employed in the masonry works of that basin many thousand tons of Portland cement. We have thus been able to make some observations, which have been checked by experience upon a large and a small scale, upon the qualities which ought to be sought for in this cement, and the best conditions for its employment. Our first researches had reference to the influence of the density of the cement upon its quality.

We took a certain volume, v, of light cement—a cement weighing about 1200 kilogrammes to the metre cube, the weight of it being ascertained by means of a box containing 100 litres, which was filled so as to avoid the pressing of the cement in the most perfect manner possible. We mixed this with two volumes, 2 v, of gravel, and then, after carefully stirring them, we made them into bricks of sixteen centimetres sectional area. We then weighed the same weight of the first choice heavy cement—a cement which weighed 1500 kilogrammes to the metre cube—whose volume v was rather less than the volume v, and we mixed this with 2 v of gravel likewise. We made this mixture into bricks, in the same manner as the first.

The resistance of an effort tearing the specimens asunder were:

	5 days.	15 days.	1 month.	3 months.
	Kilos.	Kilos.	Kilos.	Kilos.
Mortar of light cement.....	45	90	90	130
v cement 2 v gravel.....	65	70	90	130
	45	70	90	130
Average	51	76	90	130
Or in English pounds.....	112½	167½	198	286
	Kilos.	Kilos.	Kilos.	Kilos.
Mortar of heavy cement.....	65	130	130	190
v cement + 2 v gravel.....	85	130	150	190
	85	130	170	210
Average	78	130	150	196
Or in English pounds.....	173¾	286	330	432¼

Thus proving the incontestable superiority of the heavier cements.

We asked M. Hervé Mangon to analyze these cements at the School of the Ponts et Chaussées, and he found they were of the following composition:

	Light cement.	Heavy cement.
Silica	26·30	21·45
Alumina and peroxide of iron.....	8·75	8·70
Lime.....	62·35	65·60
Sulphuric acid.....	0·35	0·45
Water and loss.....	2·25	0·80
	100·00	100·00

"These analyses prove distinctly," he further wrote, "that the second sample alone approached the true type of Portland cement, while the composition of the first sample was much nearer the composition of the cements which have a rapid setting, such as the Roman cements of Pouilly, Vassy, &c." M. Hervé Mangon then dissolved and shook up, in a cold state, two grammes of each sample in half a litre of water, containing 10 grammes of the nitrate of ammonia. After a contact of twenty hours he filtered the liquid, and found in the residue of the clear liquid: Lime dissolved, 0·825 in sample No. 1; 0·505 in ditto No. 2. Thus the product of this comparatively feeble dissolvent was less in the same proportion as the quality of the cement was better. M. Hervé Mangon terminated his letter in these words: "I cannot take upon myself to affirm that the manufacturers may not succeed in making a cement that should possess the bulk of the properties of Portland cement, and yet should be of a light specific gravity. Many trials are being made with that object. Some of these have yielded curious results; but this is certain, in my opinion at least, that in the existing state of the manufacture of cements it is impossible to unite,

in the same product, the lightness of the material with the precious qualities of the true Portland cement. I think, then, that it would be advisable to forbid the use of light Portland cement in all government works until new experiments, continued over long periods of time, should allow of this rule being set aside, which, I may add, is dictated by the most simple rules of common sense."

The actual inferiority of the light Portland cements, compared with the heavier varieties, being peremptorily proved by the facts above recorded, the administration would have the greatest possible interest in substituting, in the specifications that it issues, the dosing by weight to the dosing according to volume. It would thus relieve the contractors from any question of the density of the compound, and these men exercise the most regretable pressure upon the manufacturers, in order to obtain the lightest cements possible. It would, at the same time, render frauds more difficult, if not impossible, without the connivance of the agents charged with the superintendence. Now-a-days, as M. Hervé Mangon justly remarks, these weigh-bridges are instruments as simple as they are economical; the dosing of the mixture of cement and sand by weight has become as practical a method as the dosing by volume.

Here it is necessary to define what is meant by heavy cement. We shall hereafter call cement "heavy" when its weight, ascertained by the means of a box of the capacity of 100 litres, (that is a parallelopipedon of right angles of 0·50 m. long, by 0·50 m. broad, by 0·40 m. deep,) filled in a manner to avoid the pressure as much as possible, should never be less than 1350 kilogrammes in weight per metre cube, without the box. According to the mistaken notions of the marine engineers, (for a proof of which we may refer to the last specifications issued at Cherbourg,) we should say, perhaps, more exactly, a heavy cement is one whose specific gravity is superior to 1200 kilogrammes, when, for the purpose of ascertaining this gravity, the cement is poured in, without pressure, a measure of a litre, of a capacity of 1·10 on the side. For the purpose of ensuring greater exactness the litre ought to be filled twenty-five times in succession, with the same precautions, and the specific gravity will be ascertained from the results of the twenty-five weights thus formed.

It is to be observed, that the heavy cements generally set with less rapidity than the light cements. Thus, when such cements are employed, it is not advisable to attach much importance to the proof after the first forty-eight hours, which is, nevertheless, very convenient in general works, as it permits the stock to be renewed more readily. The proof after the lapse of five days can alone, with these heavy cements, be considered conclusive.

Mode of using Portland Cement Concrete under Water.—The concretes of Portland cement that are immersed in water suffer an energetic washing, which is to be accounted for by the fact that every piece of stone that comes in contact with the water is immediately deprived of the mortar which surrounds it; it does not, in fact, retain a trace of this mortar. Portland cement mortar is not rich and soapy,

in the style of the lime mortars, properly so-called. It does not stick to the trowel, but it is like pounded glass that is moistened, so bad an aspect does it present when it is rather stiff. Treated with sea-water, this mortar separates in three parts or strata. The upper stratum, A, is only a simple lime water; it does not set, remains soapy, unless it is dried. The middle part, B, acts as would a mortar that is of the kind known as "thin;" whilst the residue, C, appears alone to preserve some qualities of the mortar; but composed as it is of the heaviest grains, which are also the best burnt portions of the cement, it does not set with anything like rapidity. It is, moreover, diminished in strength by the mixture of a great part of the gravel, which enters into the composition of the mortar, which falls with it into the intervals which are left between the stones. Indeed, the density of the Portland cement is much nearer that of gravel than that of lime. It would appear then that the tendency of the elements of the mortar to separate would be less in the case of Portland cement mortars than it would be in those made of ordinary lime. But there is not the same adhesion in the grain of Portland cement to the materials with which it is mixed. Moreover, the cements that are met with in commerce do not weigh more than 1200 kilogrammes, when not pressed, and measured in a box containing 100 litres. The best gravel from the shore of Boulogne, measured in the same way, weighs as follows: 1 degree, when very dry, nearly 1700 kilogrammes; 2 degrees, when moist, nearly 1500 kilogrammes. Adopting this last figure, the density of the gravel would only be 25 per cent. greater than that of light Portland cement. But in salt water this difference between the densities of the cement and the gravel becomes notably exaggerated; for the effective weights in salt water become 200 and 500 kilogrammes, that is to say, that after the immersion the weight of the gravel would be found to be more than double that of the cement. It is this fact that may account for the ready separation of the elements that enter into the composition of the mortars that takes place in water.

M. Hervé Mangon has kindly repeated this experiment of washing, with pure cement. The cement that he operated upon presented the following composition:

	At moment of arrival.	Supposed deprived of the water.
Silica	25·60	26·61
Alumina and peroxide of iron	8·95	9·30
Lime	61·35	63·77
Magnesia	0·30	0·32
Water, carbonic acid, and matters not dosed	3·80	.....
	100·00	100·00

It weighed 1440 grammes when it had been sifted, and it left, in the course of that operation, the following results:

Grains of 1½ millimetre diameter	0·70
Grains varying from 1½ to 1 millimetre diameter	0·70
Grains varying from 1 to ½ millimetre diameter	0·40
Grains stopped by a sieve 36 meshes to the centimetre	28·20
Powder passing through a sieve 36 meshes to the centimetre	70·63
	100·00

The cement in its natural state, and mixed with the ordinary precautions, sets immediately under water. The parts that were extremely fine also set with equal success. The grains that were kept back by the sieve did not work up well, and they retained the appearance of sand; but with time, and even under water, this product set, and acquired a considerable degree of hardness. Thus the cement fulfilled all the conditions that were required, either as regards the chemical composition, the burning, the density, or the degree of pulverization. M. Hervé Mangon then dissolved in ten litres of water 800 grammes of this cement; he shook it, and then he poured off the water that had been allowed to clear itself. Lastly, he poured the cement thus washed into a smaller vase, where it divided itself into three layers, which presented the following differences, according to the chemical analysis:

	A.	B.	C.
Silica	7·15	10·20	22·30
Alumina and peroxide of iron	5·30	3·00	4·30
Lime	18·80	25·60	48·00
Magnesia	2·00	1·00	0·30
Water, carbonic acid, and matters not dosed, traces of the chlorides and sulphides	66·75	59·40	25·10
	100·00	100·00	100·00

Or, supposing these mortars to be deprived of the water and the carbonic acid that they contained, their composition would become—

	A.	B.	C.
Silica	21·5	25·2	29·7
Alumina and peroxide of iron	15·9	9·3	5·7
Lime	56·6	63·1	64·1
Magnesia	6·0	2·4	0·5
	100·0	100·0	100·0

The layer A was, in fact, a pure lime water; the lime was in part replaced with magnesia, which, being more voluminous than it was, opposed everything like a cohesion of the product. The layer B having been thinned by the mixture of a small portion of the cream of lime, was principally distinguished from the layer C by the differences

in the physical states of the layers. The layer C alone set in a satisfactory manner. In this case, again, the chemical analysis explained sufficiently the facts that had been experimentally observed. It must, however, be said that, in the opinion of M. Hervé Mangon, there does not exist, in the actual state of the fabrication of cements, a product of that nature which would resist such an energetic washing, particularly in sea-water.

This being settled, let us examine the conditions of the laying of the beton on the level of the water and under the water.

Case the first.—The ordinary practice—that consists in laying the fresh concrete a little behind the mass already in place, and then compressing it by rammers, so as to cause the wet concrete to swell and advance forward, while it always presents the same surface to the part in advance—is not possible with the Portland cement; the mortar is not sufficiently stiff, it is not soapy enough for that. The long slidings, which are occasioned by the widening of the mass that is spread out, and which is flattened in laying, causes the beton made with lime to advance slowly, and it is accompanied with an insensible degree of washing. These slidings do not take place with Portland cement, generally speaking. It is almost impossible to keep up a gentle slope with this description of beton. Now, when the slopes are very steep, the stones detach themselves and roll down, and thus the washing is produced. In this matter there may be observed in the whole height of the mass (but particularly about the level of the surface, where the action of the waves is most distinctly felt,) through the stones that are washed clear of the mortar, caverns imperfectly filled with gravel and the coarser grains of the cement, which constitute a mortar that is very thin, that covers the rest of the cement mixed up with a cream of that material, more or less mingled with the cement. Above the water the concrete is excellent.

Let us now consider the case wherein the concrete is executed under water, by means of boxes of a capacity which, as will be seen hereafter, it is advantageous to make as large as possible. The heaps of concrete are disposed one by the side of the other, but which have necessarily their slopes very steep, for the reasons before enumerated. In each heap the heart alone can be very sound, so that, if the position should contain any springs, it is tolerably certain that they will appear upon the surface of the layer of concrete when the excavation of the interior shall be laid dry; the springs will, in fact, follow the lines of the washed stones. It is true that these effects may be produced with lime mortars; but we believe we may affirm, without fear of being contradicted by fact, that they are much more serious with the beton made with Portland cement. The layers of mortar made of lime flatten more; we have in their case to deal with a complete layer, not with heaps that are juxtaposed. But, laid dry, the concrete made with Portland cement reassumes all its advantages over the concrete made with lime. Thus we have often noticed that a spring from below has forced a passage through the concrete made with Portland cement, like a hole pierced by a ball; the water had passed through, but the concrete only allowed its passage through the passage that

was strictly necessary. All around the hole, from the top to the bottom of the spring, the cement mortar retained its goodness. The concrete was pierced like a chimney whose diameter was reduced to just the dimensions that are absolutely necessary.

In the same manner water runs over fresh concrete without any serious consequences, except in the case of great speeds and great falls. To fill, by the means of the basin of the floating dock of Boulogne, that reserved portion, we had formed, with complete success, on one-half of the width of the passage, the first portion of the bed of concrete, the water being allowed to flow over the other part; afterwards we passed over the fresh bed of the current—the stream of water that was retained by a rim formed in the earth—and we filled the half that had remained empty, and thus on, successively passing the water over two sides.

We have thought that the stability—if we may express it thus—of the Portland cement mortar was in a great measure due to its great weight, which is more than half as much again as that of ordinary lime. In fine, if the concrete made with cement is with difficulty applied in water, it is possible to apply it dry in land charged with springs without inconvenience. If, however, it were absolutely necessary to apply it in water, we would recommend the use of machinery, in the style of "tremies," in preference to any others; for the two facts we have mentioned prove that a layer of Portland cement concrete may be spread under the water with the tremies with less alteration than a similar layer of lime mortar. We also would recommend that the concrete should be made with round stones, rather thin, with angular stones that are the result of the breaking of the ballast, for it is extremely important to facilitate the sliding of the materials one upon another, to make up for the want of an unctuous character in the Portland cement. We may here observe that a round pebble from our shore seemed to us as difficult to detach from a gangue of Portland cement mortar as a stone that was broken could be.

Mode of using Portland Cement Mortar in Masses of Masonry.—In the execution of masses of masonry, we think it is a good practice to employ the mortar of Portland cement sufficiently soft, so that it should more easily assist in the formation of beds that would form the seating of the stones, otherwise there is danger of the formation of many vacua under the masses; for the stiff Portland mortar acts as ordinary earth when it is worked with the trowel. Soft, however, it assumes a distinct character; it becomes more unctuous, and spreads more easily in the beds.

An excess of water, as might have been expected, has produced a weakening of the mortar; but if the stiff mortar yields resistances that are superior to those of fluid and very fluid mortars, it does not yield results that are comparable to those of the normal mortar, even when this is mixed with a great quantity of water.

Under stones used as ashlar and laid in elevation, the mortar of Portland cement which does not stick to the trowel (we may observe, moreover, that the ashlar stones of the floating basin at Boulogne, which are obtained from the carboniferous limestone of the valley of

Hereuse, in the neighborhood of Marquise, are of a marble that is very smooth,) tends, in throwing off the excess of its moisture, and in hardening, to allow the formation of hollow spaces by the effect of shrinkage under the beds, of which the existence is brought to light in times of rain. Thus, by reason of the porosity of the material, the rain-water, driven by the wind, can fill up the hollow spaces, which are made apparent, when the rain ceases, by the permeation of the moisture. The greatest care must, therefore, be taken to ensure the strict obtainment of the beds that should be perfectly resisting, and this would imply great skill on the part of the mason charged with the setting.

The following seems to us the best method to be observed in these cases: The workmen commence by spreading upon the beds of masonry a layer of mortar of two or three centimetres thick that is sufficiently stiff; they place about the angles of the face two wedges of a wood that is very tender, and these are driven in throughout their length; they equally wedge up with a piece of stone the back side of the stone that is intended to be laid; then the front wedges are gradually withdrawn, and the piece of stone then is inserted in the opposite direction, the stone being forced down to its place with blows of a mallet. The wooden wedges do not serve in this case to do more than prevent the stone from floating upon its bed of mortar. They hinder in this manner the undulation of the layer; they can be easily withdrawn by hand as soon as the bed of mortar has hardened a little.

The shrinkage that the Portland cement is exposed to ought to cause its rejection for the use of pointing mortars that are too rich. The best composition of this description of mortars seems to us to be that which is produced by a mixture of 700 parts of Portland cement to 1000 parts of gravel. To diminish as much as possible the porosity of the joints, it is necessary to stipulate for a most energetic method of the compression of them by the tool that is used to draw the joints—in French, by the *dagne*. The mortar is, moreover, much solidified by this operation. Now, we have had occasion to observe, practically, that bricks made with compressed mortar offer a resistance that is much greater than in bricks which are made in ordinary mortar prepared in the ordinary manner.

Amongst the remarkable properties of Portland cement mortars, it is important to mention that it is beyond the effects of frost. The Portland cement mortars do not freeze, as our masons say; and this allows the execution of masonry in the cement in the winter season in cases of need. Thus, portions of Portland cement mortar which we had exposed to the frost immediately after they were prepared, had cracked very deeply after they were made, and before they had taken their definite form, in consequence of the freezing of the water, and had even partially fallen to pieces to a great extent, but, after the thaw, had preserved, in the detached morsels, the greatest hardness.

We will terminate this note by some words upon the influence of the degree of tenacity of the inert matters mixed with the cements, and upon the ultimate resistance of the mortars. We for this purpose made bricks that were composed of the following ingredients, namely,

Rich mortar, } 1 of Portland cement and 2 (in bulk) of the gravel of la Creche.
} 1 of Portland cement and 2 of the Downs sand, (all in bulk.)
Thin mortar, } 1 of Portland cement and 4 of the gravel of la Creche.
} 1 of Portland cement and 4 of sand.

The sand that was obtained from the Downs was employed very fine; it did not leave any residue upon a sieve of eighteen meshes to the centimetre. The grains of gravel, on the contrary, were retained in about the proportion of one-third by this dimension of hole. We obtained the following resistance to tearing asunder that are found in this table:

Composition of the bricks.	Weight producing rupture by tearing asunder after—											
	5 days.		1 month.		3 months.		6 months.		1 year.		2 years.	
1 vol. Portland cem't	45	46·67	80	90·00	100	120·83	160	167·50	200	183·33	190	196·67
	45		80		110		140		180		210	
	50		100		100		165		180		190	
	50		100		140		180		170			
1 sand	45		90		135		175					
	45		90		140		185					
1 cement...	40	43·00	80	96·67	110	104·50	145	146·66	180	155·00	190	190·00
	40		80		120		145		150		190	
2 fine sand	42		110		117		145		160			
	42		110		80		155		160			
	47		100		100		150		140			
	47		100		100		140		140			
1 Portland	7·00	5·50	25	26·67	110	104·50	40	63·40	88	81·25	190	190·00
	2·50		30		120		45		80		190	
	7·00		25		117		53		80			
4 gravel...	7·00		25		80		94		80			
	7·00		25		100		85		80			
	7·00		25		100		85		80			
1 Portland	2·50	2·50	10	10·67	110	104·50	15	30·20	35	38·50	190	190·00
	2·59		12		120		25		42		190	
	2·50		10		117		36		42			
4 fine sand	2·50		10		80		80		42			
	2·50		10		100		25		42			
	2·50		10		100		25		42			

It follows that the relation of the loads carried by the rich and the thin mortars, or those that were mixed with large proportions of sand, were as follows:

	After 5 days.	After 1 month	After 3 months.	After 6 months.	After 1 year.
Rich sand / Grav'l	$\frac{43·00}{40·67} = 0·92$	$\frac{96·67}{90·00} = 1·07$	$\frac{104·50}{120·83} = 0·86$	$\frac{146·66}{167·50} = 0·87$	$\frac{155·00}{183·33} = 0·85$
Thin sand / Grav'l	$\frac{2·50}{5·50} = 0·45$	$\frac{10·67}{26·67} = 0·41$		$\frac{30·20}{63·40} = 0·48$	$\frac{38·50}{81·25} = 0·41$

After 2 years it was for rich mortars $\frac{190·00}{196·67} = 0·96$.

This would lead to the prescription, in a general manner, of the use of fine sand in the preparation of thin mortars.

These materials are, then, carbonate of lime, nearly pure, to which the sea-water has added a little magnesia. We find, moreover, similar matters everywhere, that the water can penetrate through the mortar that is made of cement.

MECHANICS, PHYSICS, AND CHEMISTRY.

A Powerful Source of Artificial Light. By WILLIAM H. HARRISON.

From the British Journal of Photography, May, 1866.

One of the most brilliant discoveries made within the last few years has just been made public by its inventor, who has not only discovered a new principle in electrical science, but has applied it to the construction of a machine which, by means of the carbon points, will give light of much greater brilliancy than has hitherto been produced by man. The present apparatus is made on a grand scale, but it remains to be seen whether a small machine cannot be made to work by hand, whereby the electric light can be produced at the mere cost of the labor and the carbon electrodes. So powerful is the current of electricity evolved by the present apparatus, that ordinary photographic paper, at two feet distance from the light, blackens in twenty seconds to the same degree that it will darken by exposure for one minute to the direct rays of the noon-day sun on a clear morning in the month of March.

This invention was first made known to the public by Professor Faraday, a week or two ago, at a meeting of the Royal Society. The paper containing the information was a very long one, sufficient to fill more than a whole number of this *Journal*, and was written by the inventor, Mr. H. Wilde, of Manchester. Some notes of the substance of its contents, and the marvelous effects produced by the powerful currents evolved by the apparatus, will be of interest, considering the promise of the invention when regarded from a photographic point of view.

Mr. Wilde first made a large hollow metallic cylinder, with sides of iron, separated by a thick diaphragm of brass. This composite cylinder had its metallic parts bolted together by screws of brass. Permanent magnets could be placed over the cylinder, so that their poles would bite and make good contact with the opposite iron sides. The internal diameter of the cylinder was 1⅝ inch. The four or five horse-shoe magnets which could be placed over it, each weighed about one pound, and would each sustain a weight of ten pounds. Thus, when the magnets are mounted over the cylinder, the two iron sides of the latter become virtually the poles of one very powerful magnet. The armature is a long solid bar of soft iron, made to revolve inside the hollow portion of the cylinder. This solid bar has a deep longitudinal groove on each side of it, in which groove the insulated wires of the armature are placed, so that the latter has still a cylindrical form ex-

ternally. It will be noticed that this arrangement is, in principle, that of the ordinary magneto-electric machine, though somewhat differing in form from those of the usual construction.

With apparatus thus arranged, Mr. Wilde connected the terminal wires of the armature with a common tangent galvanometer, to measure the electricity evolved as each permanent magnet was added to the outside of the cylinder. He found that the electricity produced was in direct proportion to the number of magnets on the cylinder. But now comes the wonderful part of the discovery. When the induced current of electricity from the armature was passed round an ordinary electro-magnet, the soft iron bar, the latter actually lifted 178 lbs., whilst the four permanent magnets on the cylinder, the original source of the power, would only lift a weight of 40 lbs. The effect here produced seems to be out of all proportion to the cause, and it will be seen what an important bearing the discovery has upon the law of the conservation of energy. Having made this first step, Mr. Wilde constructed a second cylinder, larger than the first, and placed outside it electro-magnets instead of permanent magnets, the two machines being then worked together, and the current generated by the first being employed to excite the electro-magnets of the second. By this arrangement twenty-four inches of No. 20 iron wire, 0·04 inch in diameter, were made red-hot. Lastly, a machine with an iron armature ten inches in diameter was made, the total weight of the whole apparatus being four and a half tons. The three machines were then made to work together, the armature being driven, as before, by steam power, the results proving most astonishing. Pieces of cylindrical iron rods, each a quarter of an inch in diameter and fifteen inches in length, were melted by the current, which also melted seven feet of No. 16 iron wire, 0·065 of an inch in diameter, and made twenty-one feet of the same wire red-hot. Mr. Wilde says: "The illuminating power of the electricity from the intensity armature is, as might be expected, of the most splendid description. When an electric lamp, furnished with rods of gas-carbon half an inch square, was placed at the top of a lofty building, the light evolved from it was sufficient to cast the shadows from the flames of the street lamps a quarter of a mile distant upon the neighboring walls. When viewed from that distance the rays proceeding from the reflector have all the rich effulgence of sunshine. Lastly, as already stated, photographic paper is blackened in twenty seconds by this artificial light, to the same extent that it can be darkened by sunlight in a minute.

Such is the substance of the wonderful discovery made by Mr Wilde. It is evident that its value to the photographer is a question of expense, there being no doubt as to its utility. As the most economical proportions of the parts of such machines become better known by experience, it is to be hoped that the maximum of light and minimum of mechanical power, will be so altered from their present relative positions that the invention will be, to some extent, available to the photographer, and render him more independent of the weather. With the exception of the mechanical power, the expenses connected with

the working of the apparatus are nominal. Ordinary wear and tear, the consumption of the carbon points, and the gradual burning away of the contact places of the necessary commutators, are inexpensive items, offering no impediment to the general use of the machine. Whether the expense of the mechanical power can be so reduced as to make the invention commercially available in the photographic world, is the only question hanging over one practical application of this, one of the noblest scientific discoveries of modern times.

On a Convenient Process for Preparing Oxygen. By M. FLEITMANN.*

From the London Chemical News, No. 287.

The easy preparation of oxygen for technical purposes is a matter of considerable importance, and I now shortly describe a process which possesses particular scientific interest. I was led to the process by observing that on heating a concentrated solution of chloride of lime, with only a trace of freshly prepared moist peroxide of cobalt,† the hypochlorite of lime was completely decomposed into chloride of calcium and oxygen. Repeated quantitative experiments, the results of which I have lost, convinced me that the whole of the oxygen was evolved, and that only chloride of calcium and no chloric acid was formed.

The evolution of oxygen commences about 70° or 80°, and continues in a regular stream, with a slight frothing of the liquid.

The action of the peroxide of cobalt in this case, it is clear, is exactly like that of nitric oxide in the manufacture of sulphuric acid. There is no doubt that several peroxides of cobalt, with various proportions of oxygen, exist. My own experiments have shown me that the proportion of oxygen in peroxide of cobalt is variable, and the simplest explanation of this process is that a lower peroxide abstracts oxygen from the hypochlorite of lime to form a higher oxide, which is again decomposed into a lower oxide and oxygen.

The peroxide made use of in one experiment may be employed again to decompose a fresh quantity of hypochlorite of lime. From one-tenth to one-half per cent. is sufficient to effect the reaction; and instead of taking the freshly prepared hydrated peroxide, it will suffice to add to the solution of hypochlorite a few drops of a solution of cobalt salt, whereby a corresponding amount of the peroxide is formed.

The advantages of this method of procuring oxygen appear to be the following:

1. The evolution proceeds with extraordinary regularity, and the gas is collected with the greatest ease, which makes the process specially applicable as a lecture experiment. When the mixture has been heated to 70° or 80°, the lamp may in general be removed, as the heat of the fluid is then sufficient to carry on the reaction to the end.

* *Annalen der Chemie und Pharmacie*, April, 1865, page 64.

† Peroxide of nickel acts in a similar way, but not so energetically.

2. The *whole* of the oxygen is obtained from the material, while only a part is procured by heating peroxide of manganese, and

3. The process has the advantage of greater cheapness than that with chlorate of potash (either with or without manganese.)

It is necessary to employ a clear solution of chloride of lime, as a thick or murky solution will froth over. The best way of making a clear and strong solution is by first extracting one portion of chloride of lime with water, decanting the clear liquor, and then making use of that to exhaust another portion of the chloride. In this way it is easy to get a liquor which will evolve from twenty-five to thirty times its volume of oxygen. On the small scale it is best to employ a capacious flask, which may be about seven-eighths filled with the solution. On a large scale, for technical purposes, a sort of steam boiler might be used, and the oxygen so obtained under pressure, and capable of being employed as a blast.

In a note the author suggests that a very pretty experiment may be made to show the displacement of oxygen by chlorine, by passing the latter gas into a mixture of solution of caustic soda with some peroxide of cobalt. The chlorine could be passed in on one side, and oxygen collected at the other.

The Chemistry of Gas Lighting. By Dr. Letheby.*

From the London Mechanics' Magazine, December, 1864.

The lecturer remarked that the object he had in view in the present instance was to take a rapid survey of the entire subject of the chemistry of gas manufacture. He did not intend to dwell particularly on any special set of facts; for, although every branch of the subject was full of interest, and might well be made the basis of elaborate investigation, yet the time at his disposal would not permit of anything more than a general and very cursory examination of the whole question. He would endeavor, therefore, to gather up the broad principles of chemical knowledge in this department of industry, and indicate their directive tendency. He hoped at a future time to have the opportunity of examining in detail the several branches of the subject; and at the very commencement of the inquiry it would be interesting to know something of the origin of the material upon which, as gas manufacturers, they had to operate. The question which here suggested itself was: Does chemistry throw any light upon the production of coal? There could be no doubt that it owed its origin to ligneous tissue. But how had it undergone those changes which had converted it into coal? Chemistry had pretty fully investigated this subject, and had shown that the production of coal was clearly traced to the eremacausis, or slow combustion of ligneous tissue; and in looking at the modes of oxidation of woody matter, it would appear that there were three ways in which it could be, and no doubt was,

* Abstract of a lecture delivered at Manchester before the British Association of Gas Managers.

effected. In the first place, it was partly effected by an internal change in the wood itself, whereby the elements—oxygen and hydrogen—associated and formed water, leaving the carbon free. In the second place, it was accomplished by the agency of water, the elements of which combined with carbon to form carbonic acid and marsh gas; and, thirdly, it was effected by the action of atmospheric oxygen slowly carried to the woody tissue by percolating water. All these changes were illustrated by diagrams and by specimens of wood in every stage of change, from lignite and Bovey coal to anthracite.

Formation of Coal.

Oak wood	$C_{36} H_{22} O_{22}$
Oak humus	$C_{35} H_{20} O_{20}$
Another humus	$C_{34} H_{18} O_{18}$
Brown coal	$C_{33} H_{21} O_{16}$
Another coal	$C_{32} H_{15} O_{9}$
Cannel coal	$C_{24} H_{13} O$
Caking coal	$C_{20} H_{9} O$
Anthracite	$C_{16} H O$

It was scarcely within the province of the present lecture to enter upon a detailed inquiry as to the best kinds of coal for the manufacture of gas, and he did not propose to say more than that the coal must be of that description called bituminous. But it was a matter of considerable importance to know whether any particular coal would yield a fair average proportion of gas without submitting it to minute analysis. In referring, therefore, to the varieties of coal which were best suited for the manufacture of gas, he directed attention to the rough

Composition of Gas Coals.

	Sulphur.	Ash.	Coke.	Volatile Matter.
Staffordshire—				
Maximum	3·10	3·50	66·00	42·90
Minimum	0·80	0·75	57·10	34·00
Average	1·71	2 01	61·61	38·39
Lancashire—				
Maximum	3·04	14·40	66 09	48·90
Minimum	0 52	1·09	51·10	33·91
Average	1·53	4·71	58 67	41·33
Newcastle—				
Maximum	2·85	9·12	72·31	45·17
Minimum	0 71	2·14	54·83	27·69
Average	1·29	4·52	61 24	38·76
Scotch—				
Maximum	1·58	8·05	59·15	45·06
Minimum	0·38	1·96	54·94	40·85
Average	1·22	5·46	57·32	42·68
Yorkshire—				
Maximum	1·40	10·50	66·90	38·00
Minimum	0·75	0·80	62·00	33·10
Average	1·19	2·96	64·37	35·63
Welsh—				
Maximum	2·30	7·55	88·23	41·58
Minimum	0·84	1·25	58·42	11·77
Average	1 09	3·66	64·37	35·63

test whereby the value of coal might be estimated; as, for example, the specific gravity of the specimen, which should be close to 1·3, and the loss encountered when a given quantity of the coal (say 100 grains) was ignited in a close vessel. The quality of the residue or the coke was also an indication of the value of the coal for gas purposes; and the lecturer exhibited a diagram of the average, the maximum, and the minimum amounts of coke and volatile matters in all the leading varieties of coal.

But there were certain impurities in coal which it became necessary to recognise. The three principal were ash or mineral matter, sulphur, and water, each of which had a very important influence on the manufacture of gas. The normal proportions of these impurities were illustrated by a series of diagrams of the compositions of various gas coals.

The modes of estimating these impurities were also referred to; and, in speaking of sulphur in coal, the lecturer alluded to the importance of making a selection of coals as free from it as possible, for Parliamentary legislation was manifestly towards the growing desire of the public to have gas with a minimum amount of sulphur. The means of determining the proportion of sulphur in coal were pointed out, and were illustrated by experiment. But, said the lecturer, there is another important question connected with this impurity in coal; in how many forms does it exist there? and of these, which are the most pernicious? He stated that it might, to a small extent, be there in a free state, and that of the combined forms it was perhaps associated with organic matter, as well as with iron, (bisulphide of iron,) and with lime as gypsum. The relative importance of each of these forms was dwelt upon, and he spoke of the pyritic form as the most objectionable, because of its giving off its sulphur at that temperature which is most favorable for the production of bisulphide of carbon and sulpho-hydrocarbons, both of which are unabsorbable impurities. The effect of moisture as an impurity was next referred to, and the lecturer explained how, when it was being distilled from the interior of a charge, and came into contact with the protosulphide of iron which had already parted with half of its sulphur, the aqueous vapor decomposed the sulphide, and formed sulphuretted hydrogen and oxide of iron, thus adding to the cost of the preparation.

The lecturer then directed attention to the facts which had been ascertained in respect of the temperature best suited for the destructive distillation of coal. He remarked generally that the action of heat on organic matters was to disturb the existing equilibrium of affinities, and thus to give the elements an opportunity of arranging themselves into other and simpler groups. The order of the movement of the molecules of organic matter, when subjected to heat, was somewhat as follows: After the hygrometric or physical moisture had been dissipated, oxygen was the first to start in the race of thermotic change. It combined with hydrogen to form water, with carbon to form carbonic acid, and with carbon and hydrogen to form acid and spirituous compounds, comparatively rich in oxygen, and which are mixable with water. Next to move, perhaps, was the hydrogen in

its combination with carbon to form solid and liquid hydrocarbons of the nature of paraffin and paraffin oil and benzole, which were not mixable with water. At a higher temperature the nitrogen combined with hydrogen to form ammonia and with carbon and hydrogen to form pyrogenous alkaloids, and with carbon alone to produce cyanogen. At this temperature, also, the sulphur took hydrogen to form sulphuretted hydrogen, and then carbon and hydrogen to form the sulpho-carbo-hydrogens; and, lastly, with carbon alone to form bisulphide of carbon. Finally, gaseous hydrocarbons were freely produced; and during all the time of distillation, many of the primary compounds, by coming into contact with the red-hot coke and with the sides of the retort, underwent change, and were converted into secondary products, as naphthaline, &c.

The temperatures at which these changes were effected had been tolerably well ascertained. Up to the temperature of 700° Fahr., little or no change was effected in the coal beyond the evolution of physical moisture. At the temperature of melting zinc, (773° Fahr.,) a little chemical moisture with an empyreumatic odor was produced. At 980°, which is a red heat just visible in the dark, water and fat oils—the paraffin series—begin to distil, but there is little or no gas. At 1500°, which is a cherry-red, gas of high illuminating power is copiously evolved, and spirituous oils, rich in carbon, also appear. At a full red heat, (1800°,) and from this to incipient whiteness, permanent gases of poor illuminating power, as carbonic oxide, marsh gas, and hydrogen, and pernicious sulphur compounds, are freely evolved. Practically, therefore, it may be said that the best temperature for distilling common gas coals is a cherry-red, (1500°,) and for cannel coals a full red, (1800°.)

In illustration of the difference of the products when cannel coals are distilled at a high and low temperature, Dr. Letheby alluded to the quality of the tar in the two cases. The tar produced at a high temperature was always heavier than water—specific gravity ·12 to 1·15; it dried freely in the air by oxidation; it contained hydrocarbons with such an excess of carbon, that they could not be burnt in a common lamp; they were almost totally destroyed by strong oil of vitriol; they contained sulphur, and their per centage composition was about 86 carbon, 7 hydrogen, 7 oxygen, and a little sulphur—about 0·5 per cent. Whereas the tar produced at a low temperature was lighter than water—about ·900 specific gravity; it would not oxidate or dry in the air; it contained hydrocarbons of the paraffin series, which are comparatively poor in carbon, and which can be burnt in a lamp; they are not much acted upon by strong oil of vitriol; they contain but little or no sulphur, and their per centage composition is about 84 carbon, 12 hydrogen, and 4 oxygen. So also with the gases; at a temperature below 1800° they are rich in hydro-carbons of high illuminating power, and at a higher temperature they are comparatively poor in such hydrocarbons. The nature of the coal, of course, makes a large difference in the results, but the general expression of the fact is, that high temperatures make a minimum quan-

tity of tar, rich in carbon, and much gas, with comparatively poor illuminating power, and with large proportions of sulphur compounds.

The raw gas, as it leaves the retort, consists of aqueous vapor, vapor of tar, carbonic acid, carbonic oxide, ammonia, cyanogen, sulphocyanogen, sulphuretted hydrogen, bisulphide of carbon, sulpho-hydrocarbons, hydrogen, light carburetted hydrogen, olefiant gas, &c. Most of these are useless as illuminating agents, and, therefore, the necessity for purification. Fortunately, this, to a large extent, is easily effected by a natural process of condensation. As the gases and vapors cool, the condensable portions separate as liquid products, and thus in the hydraulic main and in the condensers, the oily tar and the aqueous ammoniacal liquor separate of their own accord. The indications, therefore, of this first step of natural purification is to cool the raw gas as much as possible. But even when thus cooled it contains a large proportion of impurity which is soluble in water; and hence, the next indication is the necessity for the use of a contrivance which shall bring the gas into contact with an aqueous solvent. Looking at the variable quality or composition of ammoniacal liquor, and that the proportion of ammonia in it ranges from about 1000 grains in the gallon to about 4000, or, in other words, that the saturating power of it per gallon is from about 6 ounces of the strongest sulphuric acid to 26 ounces, it is manifest that the best and proper washing liquid is ammoniacal liquor. This ought never to leave the gas works with less than 2000 grains of ammonia in it per gallon, or with a less saturating power than 13 ounces of sulphuric acid. There is no reason, indeed, why it should not always contain nearly double this quantity of ammonia. The use, therefore, of ammoniacal liquor as a washer of the raw gas is a natural inference. It was first suggested by Mr. Hawksley, and he has put it into practice with excellent effect, for not only does the ammoniacal liquor afford a means of removing ammonia, sulphuretted hydrogen, and carbonic acid from the raw gas, but, being already saturated with hydrocarbons, it does not take up any more of these illuminating agents; besides which, it can be used as a *douche* in such quantity in a large washer, that it operates very successfully as a cooling agent. The suggestions, indeed, of Mr. Laming, that every charge of ammoniacal liquor thus used might be first filtered through hydrated oxide of iron, so as to move the sulphuretted hydrogen, and thus give it a more effective purifying power, is not without practical value. But even when the gas has been thus cooled, and has left the condensers, it is not so free from ammonia, carbonic acid, and sulphuretted hydrogen as that a small quantity of water properly distributed in a scrubber will not still further purify it, and the arrangement should be such that the water should trickle very slowly over a large surface, and reach the bottom of the scrubber almost saturated with impurities. Leaving this part of the apparatus, the raw gas should never contain more than 1 volume in 1000 of ammonia, 8 of sulphuretted hydrogen, and 20 of carbonic acid. These are in the proportion of 315 grains of ammonia, 5048 grains of sulphuretted hydrogen, and 16,336 grains of carbonic acid in 1000 cubic

feet of gas. Then comes the chemical means whereby these can be best removed, and this involves an inquiry into the action of the purifiers, as they are called.

The order in which these impurities should be taken out is a matter of no slight importance. Chemistry teaches us that the first impurity to be removed is ammonia, for its presence checks the withdrawal of carbonic acid and sulphuretted hydrogen. Among the many suggestions which have been made for the absorption of ammonia, there is none so effective as diluted sulphuric acid, and it is found that 49 parts by weight of the strongest sulphuric acid will remove 17 of ammonia. It will take, therefore, 909 grains, or rather more than 2 ounces of sulphuric acid, to remove the ammonia from the 1000 cubic feet of gas. The acid is best used diluted with about its own bulk of water, and sprinkled upon saw-dust, which should be placed first in the trays of the purifiers; and the saw-dust thus saturated with the ammonia is a valuable material, as it should contain fully half its weight of sulphate of ammonia. Other valuable absorbing agents have been proposed, as the spent acids of various manufacturing processes, the acid salt of alumina obtained by boiling clay shale with sulphuric acid, (Croll,) and the residual chloride of manganese from bleaching works. This has recently been used by Mr. Croll in the form of a nearly dry mixture with saw-dust, and it yields a salt of ammonia remarkably free from impurities.

Next after the ammonia, it is proper to remove the sulphuretted hydrogen, and unquestionably, if no sanitary considerations are concerned, the best agent for this purpose is wet lime, a material which will not only remove the sulphuretted hydrogen, but will likewise absorb the carbonic acid. Theoretically, 28 parts by weight of lime will take up 17 of sulphuretted hydrogen, and another 28 parts will take up 22 of carbonic acid. It follows, therefore, that about 3 lbs. of lime will absorb the carbonic acid, and 1¼ lb. the sulphuretted hydrogen in the 1000 cubic feet of gas, taking altogether about 42½ lbs. of lime for 10,000 cubic feet of gas. But this is on the supposition that the lime is thoroughly effective, and that it is used in a very wet state; practically, it is not so completely effective, and hence it takes about 50 lbs. of wet lime to purify 10,000 cubic feet of gas. If the lime is used in a dry state, (as a hydrate,) it is by no means so effective, for it requires fully twice the quantity of lime to purify the gas. This is due to the circumstance that the interior of the little lumps of lime is never reached by the gas, and therefore remains inoperative; besides which, the lime is getting constantly drier in the purifiers by the heat of combination with the impurities of the gas, and as the lime dries, it loses its capacity for absorbing these impurities; absolutely dry lime, in fact, will scarcely absorb sulphuretted hydrogen.

The offensive nature of spent lime, or blue billy, is such that a demand has been made on science to furnish a less objectionable means of purification; and hence the use of the hydrated oxide of iron—a material which, when tolerably pure, will absorb sulphuretted hydrogen in the proportion of 17 parts of sulphuretted hydrogen to about

33 of the oxide. It will take, therefore, about 14 lbs. of the hydrated oxide to remove the sulphuretted hydrogen from 10,000 cubic feet of gas. It has then become a sulphide of iron, and has lost its power of purification, and must be revived. This is accomplished by simply exposing the oxide to the air, when it takes in atmospheric oxygen, and again passes into the state of hydrated oxide of iron, while the sulphur is set free in the mixture. The oxide thus charged is then used again and again, until it becomes charged to the extent of about 57 per cent. of sulphur, when it is no longer effective. Practically, a ton of oxide will, by successive revivification, purify about 5,000,000 cubic feet of gas, and will absorb about 3600 lbs. of sulphuretted hydrogen. When thus charged with sulphur, it is valuable for manufacturing oil of vitriol.

If hydrated oxide of iron has been used as the purifier, lime must also be afterwards employed for the purpose of removing the carbonic acid, which is so destructive of the light of the gas when it is burned.

Having left the purifiers, the constituents of the gas are as follow:

	Per cent.		
Hydrogen	25	to	50
Light carburetted hydrogen, $C^2 H^4$	35	"	52
Olefiant gas, $C_4 H_4$ Propylene, $C_6 H^6$ Butylene, $C_8 H^6$ Other hydrocarbons, $C_n H_n$ Benzole vapor, $C_{12} H^6$ Acetylene, $C_4 H^2$	3	"	20
Carbonic oxide, C O	5	"	9
Carbonic acid, $C O_2$	0	"	2
Cyanogen, $C_2 N$	?	"	?
Ammonia, $N H_3$	0·01	"	0·06
Bisulphide of carbon, $C S_2$	?	"	?
Sulpho-hydrocarbons	?	"	?
Aqueous vapor	2	"	3
Oxygen	0	"	1
Nitrogen	0	"	8

The properties of each of these constituents were demonstrated by experiment, and reference was made to their specific gravities, to their combining volumes, to the proportion of oxygen which they required for combustion, to the quantity of carbonic acid so produced, to the heat evolved, and to the action of water, chlorine, bromine, and anhydrous sulphuric acid upon them.

One of the interesting features of this part of the lecture was the production of acetylide of copper from the coal gas of the hall, and the exhibition of acetylene in large volume; as also the production of nitro-benzole from the gas, by passing it through fuming nitric acid.

As regards the means of determining the proportions of the condensable hydrocarbons in coal gas, Dr. Letheby showed that, as all the illuminating constituents of coal gas, excepting the light carburetted hydrogen, were absorbed by bromine and by anhydrous sulphuric acid, neither of these tests were worth anything as an indication of the illuminating power of the gas. In speaking of acetylene, he alluded to the fact that its production by the intense ignition of carbon in hydrogen was a remarkable example of the production of a hydrocarbon by the immediate combination of its elements; and he observed that

as acetylene, which is such a powerful illuminating agent, may be made by the action of carbonic oxide on light carburetted hydrogen at high temperatures, it is possible that hereafter it will be found that by a proper arrangement of apparatus, a high temperature may be best suited for the production of illuminating gas. The sole difficulty,

Principal Constituents of Coal-tar.

	Formulas.	Boiling points. Degrees Fahrenheit.
Acids—		
Acetic	$C_4 H_4 O_4$	248
Butylic	$C_8 H_8 O_4$	315
Phenic	$C_{12} H_6 O_2$	370
Cresylic	$C_{14} H_8 O_2$	397
Phlorylic	$C_{16} H_{10} O_2$	...
Rosolic	$C_{24} H_{12} O_6$	...
Brunolic	?	...
Neutral—		
Propylene	$C_6 H_6$	...
Butylene	$C_8 H_8$	54
Amylene	$C_{10} H_{10}$	102
Caproylene	$C_{12} H_{12}$	131
Alliaceous	?	?
Benzole	$C_{12} H_6$	176
Toluole	$C_{14} H_8$	237
Xylole	$C_{16} H_{10}$	259
Cumole	$C_{18} H_{12}$	302
Cymole	$C_{20} H_{14}$	347
Naphthaline	$C_{20} H_8$	414
Anthracene,	$C_{28} H_{10}$	...
Paraffin	$C_n H_n$	...
Pyrene	$C_{20} H$	...
Chrysene	$C_{12} H_4$	...
Alkalies—		
Ammonia	$H_3 N$	...
Methylamine	$C_2 H_5 N$	...
Ethylamine,	$C_4 H_7 N$	66
Petinine	?	176
Cespitine	$C_{10} H_{13} N$	205
Pyrrhidine	$C_{10} H_5 N$	271
Picoline	$C_{12} H_7 N$	273
Lutidine	$C_{14} H_9 N$	309
Collidine	$C_{16} H_{11} N$	338
Aniline	$C_{12} H_7 N$	360
Parvoline	$C_{18} H_{13} N$	370
Toluidine	$C_{14} H_9 N$	388
Coridine	$C_{20} H_{15} N$	412
Xylidine	$C_{16} H_{11} N$	415
Cumidine	$C_{18} H_{13} N$	437
Rubidine	$C_{22} H_{17} N$	446
Cryptidine	$C_{22} H_{11} N$	...
Leucoline	$C_{18} H_7 N$	455
Cymidine	?	462
Viridine	$C_{24} H_{19} N$	484

perhaps, to be overcome will be the formation of carbonic oxide and marsh gas in proper proportions.

With respect to the existence of sulphur compounds in coal gas,

Dr. Letheby demonstrated by many experiments that sulphide of carbon and one or more sulpho-hydrocarbons were always present; and he showed the patented processes of Mr. Bowditch, Dr. Stenhouse, and Dr. Angus Smith, for removing these sulphur compounds. He referred also to his own apparatus for estimating the amount of sulphur in purified coal gas; and he likewise explained the means of determining the proportion of ammonia in gas, and he spoke of this impurity as a purveyor of the offensive tar-like hydrocarbons.

A slight reference was made to the subject of coal-tar, and to the large field of chemical research which it had exposed to the chemist; and a few of the more interesting of the coal-tar pigments were made, and nearly all the products were exhibited on the table, (*page* 44.)

Lastly, in respect of the chemistry of the combustion of gas, Dr. Letheby showed under what circumstances it was best consumed, and he demonstrated in various ways, as by Erdmann's gas-prover, that the proper illuminating power of coal gas could only be obtained by an accurate adjustment of the air to the gas. This was chiefly accomplished in the Argand burner by a proper adaptation of the internal aperture to the quality of the gas; a burner of only 0·42 of an inch internal bore, was well suited for 11-candle gas, one of 0·44 of an inch for 13-candle gas, and one of 0·50 of an inch for 15-candle. In each of these cases the burner is used without a gauze diaphragm, and with a 7-inch chimney, the gas being burned at the rate of 5 feet an hour; but the same result and a steadier flame is obtained by using Sung's burner of a little smaller diameter of the internal hole in each case, and a gauze diaphragm. By experiment with Leslie's burner, which is altogether unsuited for gas of low illuminating power, it was shown that the light of the gas might be seriously destroyed.

The relative values of different illuminating agents were shown by the following table:

Relative values of Illuminating Agents in respect of their Heating and Vitiating Effects on the Atmosphere, and Burning so as to give the Light of Twelve Standard Sperm candles.

	Pounds of water heated to 1° Fahr.	Oxygen consumed, (cubic feet.)	Carbonic acid produced, (cubic feet.)	Air vitiated, (cubic feet.)
Cannel gas	1950	3·30	2·01	50·9
Common gas	2786	5·45	3·21	80·2
Sperm oil	2335	4·75	3·33	83·3
Benzole	2326	4·46	3·54	88·5
Paraffin	3619	6·81	4·50	112·5
Camphine	3251	6·65	4·77	119·2
Wax candles	3831	8·41	5·90	149·5
Sperm "	3517	7·57	5·27	131·7
Stearic "	3747	8·82	6·25	156·2
Tallow "	5054	12·06	8·73	218·3

In conclusion, the lecturer observed that every day brought to light some new fact connected with the chemistry of gas manufacture, which deserved the careful consideration of all who, like those to whom he was addressing himself, were practically engaged in this important branch of industry. He had endeavored to lay before them, with as much fulness as time allowed, the most prominent features of the question, as far as the light of science had at present elucidated them; but the subject, in all its details, was far too complex to allow of more than a mere general statement in a compass of a single lecture.

On Scientific Experiments in Balloons. By JAMES GLAISHER, Esq., F. R. S., &c.

Proceedings of the Royal Institution of Great Britain, No. 41.

Mr. Glaisher, at the beginning, referred to the discourse given by him two years since, when he had made eight ascents, for the purpose of scientific researches, in the higher regions of the atmosphere, and said since that time he had made seventeen additional. He described the process of filling a large balloon, and briefly described a balloon ascent, speaking of the novel sensation at first experienced, of the extreme coldness and dryness of the air at great elevations, of the painless death awaiting the aërial traveler who should ascend to an elevation too great for his power of endurance, and compared it to that of the mountain traveler, who, benumbed and insensible to suffering, yields to the lethargy of approaching sleep, and reposes to wake no more. Moral energy in both cases, he stated, was the only means of safety.

He then exhibited the several instruments used, pointing out their extreme sensitiveness and delicacy, and then spoke of the primary objects of balloon research.

Subjects of Research by Means of Balloons.—1st. To determine the rate of decrease of temperature with increase of elevation; and to ascertain whether the results obtained by observations on mountain sides, viz: a lowering of temperature of 1° for every increase of elevation of 300 feet, be true or not.

2d. To determine the distribution of the water, in the invisible shape of vapor, in the air below the clouds, and above them, at different elevations.

3d. To compare the results, as found by different instruments, together:

1. The temperature of the dew point as found by—
   - Dry and wet thermometers, (free.)
   - Dry and wet thermometers, (aspirated, or air made to pass rapidly.)
   - Daniell's dew-point.
   - Regnault's dew-point, (blowing.)
   - Regnault's dew-point, (air made to pass rapidly.)
2. To compare the readings of—
   - Mercurial and aneroid barometers, &c.

4th. Solar radiation, by taking readings of the blackened bulb thermometer fully exposed to the sun, with simultaneous observations of

the dry-bulb thermometer, and also of observations of Herschel's Actinometer.

5th. To determine whether the solar spectrum, when viewed from the earth, and far above it, exhibited any difference; whether there were a greater or less number of dark lines crossing it, particularly when near sun-setting.

6th. To determine whether the horizontal intensity of the earth's magnetism was less or greater with elevation.

Propagation of sound.

Amount of ozone, &c.

In every ascent a second or third thermometer, differently graduated, has been used to check the accuracy of the readings of the dry thermometer, and the truthfulness of the temperature shown by it. In some of the ascents a delicate blackened bulb thermometer was placed near to the place of the dry-bulb thermometer, fully exposed to the sun in cloudless skies, or to the sky at all times. The readings of this instrument were nearly identical with those of the dry-bulb thermometer in clouded states of the sky, and thus acted as an additional check.

At all times, one or the other, or both, Regnault's and Daniell's hygrometers have been used sufficiently often, at all heights, to show whether the wet-bulb thermometer was in proper action, and to check the results given by the use of the dry and wet-bulb thermometer on the reduction of the observations.

The author said he would not give a detailed account of the experiments in the years 1862 and 1863, as they were published, but would confine himself to some of the results.

He said it was soon found that the state of the sky exercised a great influence, and the experiments had to be repeated with two groups, one with cloudy skies, and the other with clear skies.

The results are as follow:

The Decline of the Temperature of the Air with Elevation, when the Sky was Cloudy.

	Feet.		Feet.		Deg.				Feet.
From	0	to	1,000	was	4·2	from	17	experiments, or 1 degree in	223
"	1,000	"	2,000	"	3·6	"	21	"	278
"	2,000	"	3,000	"	3·7	"	22	"	271
"	3,000	"	4,000	"	3·4	"	20	"	295
"	4,000	"	5,000	"	3·3	"	13	"	333
"	5,000	"	6,000	"	3·2	"	7	"	313
"	6,000	"	7,000	"	2·7	"	5	"	371
"	7,000	"	8,000	"	2·4	"	4	"	417
"	8,000	"	9,000	"	2·2	"	4	"	455
"	9,000	"	10,000	"	2·2	"	4	"	455
"	10,000	"	11,000	"	2·2	"	4	"	455
"	11,000	"	12,000	"	2·2	"	4	"	455
"	12,000	"	13,000	"	2·2	"	4	"	455
"	13,000	"	14,000	"	2·3	"	4	"	435
"	14,000	"	15,000	"	2·0	"	4	"	500
"	15,000	"	16,000	"	2·1	"	4	"	477
"	16,000	"	17,000	"	1·2	"	2	"	833
"	17,000	"	18,000	"	1·3	"	2	"	771
"	18,000	"	19,000	"	1·4	"	2	"	715
"	19,000	"	20,000	"	0·9	"	2	"	909
"	20,000	"	21,000	"	1·1	"	2	"	911
"	21,000	"	22,000	"	0·8	"	2	"	1,250
"	22,000	"	23,000	"	0·8	"	2	"	1,250

These results show, when the sky is cloudy, the decline of temperature at every 1000 feet increase of elevation. Up to 5000 feet the number of experiments upon which each result is based vary from 13 to 22; at 6000 and 7000 feet to 7 and 5, respectively; from 7000 to 16,000 feet to 4; these having been made on two days, viz: 1863, June 26 and September 29, on which days the balloon was frequently enveloped in fog and clouds to the height of three and four miles, and those above 16,000 feet on the former of these two days only, during the ascent and descent, the sky being still covered with cloud when the balloon was between 4 and 5 miles high.

The Decline of the Temperature of the Air with Elevation, when the Sky was Clear, or chiefly Clear.

	Feet.		Feet.		Deg.				Feet.
From	0	to	1,000	was	6·2	from	9	experiments, or 1 degree in	162
"	1,000	"	2,000	"	4·7	"	9	"	213
"	2,000	"	3,000	"	3·8	"	11	"	264
"	3,000	"	4,000	"	3·3	"	12	"	304
"	4,000	"	5,000	"	2·9	"	12	"	345
"	5,000	"	6,000	"	2·6	"	17	"	385
"	6,000	"	7,000	"	2·5	"	15	"	401
"	7,000	"	8,000	"	2·7	"	12	"	371
"	8,000	"	9,000	"	2·5	"	12	"	400
"	9,000	"	10,000	"	2·4	"	12	"	417
"	10,000	"	11,000	"	2·6	"	13	"	385
"	11,000	"	12,000	"	2·3	"	11	"	435
"	12,000	"	13,000	"	2·2	"	11	"	455
"	13,000	"	14,000	"	2·0	"	11	"	500
"	14,000	"	15,000	"	1·7	"	9	"	588
"	15,000	"	16,000	"	2·2	"	9	"	455
"	16,000	"	17,000	"	1·9	"	7	"	526
"	17,000	"	18,000	"	1·7	"	7	"	588
"	18,000	"	19,000	"	1·5	"	7	"	666
"	19,000	"	20,000	"	1·3	"	7	"	771
"	20,000	"	21,000	"	1·2	"	7	"	833
"	21,000	"	22,000	"	1·1	"	7	"	911
"	22,000	"	23,000	"	1·0	"	4	"	1,000
"	23,000	"	24,000	"	1·3	"	2	"	771
"	24,000	"	25,000	"	1·1	"	2	"	909
"	25,000	"	26,000	"	1·0	"	1	"	1,000
"	26,000	"	27,000	"	1·0	"	1	"	1,000
"	27,000	"	28,000	"	0·9	"	1	"	1,111
"	28,000	"	29,000	"	0·8	"	1	"	1,250

Up to the height of 22,000 feet the number of experiments vary from 7 to 17, and there can be but little doubt that the number showing the decrease of temperature are very nearly true, and approximate closely to the general law. Above 24,000 feet the number of experiments are too few to speak confidently upon them, but they are in accordance with the series deduced from the experiments at less elevations.

A decline of temperature under a clear sky of 1° takes place within 100 feet of the earth, and at heights exceeding 25,000 feet it is necessary to pass through 1,000 feet of vertical height, as appears in the last column of the preceding table, for a decline of 1° of temperature.

By adding together, successively, the decline of temperature for each 1000 feet the whole decrease of temperature from the earth to the different elevations is found. The results, with a cloudy sky, are as follow:

When the Sky was Cloudy.

Feet.	Feet.		Deg.		Feet.
From 0 to	1,000	the decrease was	4·5	or 1 deg. on the average of	223
" 0 "	2,000	"	8·1	"	247
" 0 "	3,000	"	11·8	"	255
" 0 "	4,000	"	15·2	"	263
" 0 "	5,000	"	18·5	"	271
" 0 "	6,000	"	21·7	"	277
" 0 "	7,000	"	24·4	"	287
" 0 "	8,000	"	26·8	"	299
" 0 "	9,000	"	29·0	"	311
" 0 "	10,000	"	31·0	"	321
" 0 "	11,000	"	33·0	"	329
" 0 "	12,000	"	35·6	"	337
" 0 "	13,000	"	37·8	"	344
" 0 "	14,000	"	40·1	"	349
" 0 "	15,000	"	42·1	"	356
" 0 "	16,000	"	44·2	"	362
" 0 "	17,000	"	45·4	"	375
" 0 "	18,000	"	46·7	"	386
" 0 "	19,000	"	48·1	"	395
" 0 "	20,000	"	49·0	"	409
" 0 "	21,000	"	50·1	"	419
" 0 "	22,000	"	50·9	"	432
" 0 "	23,000	"	51·7	"	445

These results, showing the whole decrease of temperature of the air from the earth up to 23,000 feet, differ very considerably from those with a clear sky, to be spoken of presently. The number in the last column show the average increment of height for a decline of 1°, as found by using the temperature of the extremities of the column alone. To 1000 feet high the average is 1° in 223 feet, increasing gradually to 1° in 445 feet at 23,000 feet.

When the Sky was Clear, or chiefly Clear.

Feet.	Feet.		Deg.		Feet.
From 0 to	1,000	the decrease was	6·2	or 1 deg. on the average of	162
" 0 "	2,000	"	10·9	"	184
" 0 "	3,000	"	14·7	"	204
" 0 "	4,000	"	18·0	"	223
" 0 "	5,000	"	20·9	"	239
" 0 "	6,000	"	23·5	"	256
" 0 "	7,000	"	26·0	"	271
" 0 "	8,000	"	28·7	"	279
" 0 "	9,000	"	31·2	"	289
" 0 "	10,000	"	33·6	"	298
" 0 "	11,000	"	35·6	"	309
" 0 "	12,000	"	37·9	"	317
" 0 "	13,000	"	40·1	"	324
" 0 "	14,000	"	42·1	"	333
" 0 "	15,000	"	43·8	"	343
" 0 "	16,000	"	46·0	"	348
" 0 "	17,000	"	47·9	"	355
" 0 "	18,000	"	49·6	"	363
" 0 "	19,000	"	51·1	"	372
" 0 "	20,000	"	52·4	"	382
" 0 "	21,000	"	53·6	"	392
" 0 "	22,000	"	54·7	"	405
" 0 "	23,000	"	55·7	"	413

Feet.	Feet.		Deg.		Feet.
From 0 to	24,000	the decrease was	57·0	or 1 deg. on the average of	422
" 0 "	25,000	"	58·1	"	431
" 0 "	26,000	"	59·1	"	441
" 0 "	27,000	"	60 1	"	449
" 0 "	28,000	"	61·0	"	459
" 0 "	29,000	"	61·8	"	469
" 0 "	30,000	"	62·3	"	482

These results, showing the whole decrease of temperature from the ground to 30,000 feet, differ greatly, as just mentioned, from those with a cloudy sky.

The numbers in the last column, showing the average increase of height for a decline of 1° of temperature from the ground to that elevation, are all smaller than those with a cloudy sky at the same elevation. Each result is based upon at least seven experiments, taken at different times of the year, and up to this height considerable confidence may be placed in the results. They show that a change takes place in the first 1000 feet of 1° on an average in 162 feet, increasing to about 300 at 10,000 feet. In the year 1862 this space of 300 feet was at 14,000 feet high, and in 1863 at 12,000 feet. Therefore the change of temperature has been less in 1863 than that in 1862, and less in 1864 than in 1863, but the experiments have all been taken at different times of the year.

Without exception the fall of 1° has always taken place in the smallest space when near the earth.

Treating the observations for determining the degrees of humidity of the air in the same way, the following are the results:

When the sky was cloudy, saturation being considered as 100, the degree of humidity on the earth was	74	from	19 experiments.
At 1,000 feet	76	"	33 "
" 2,000 "	76	"	34 "
" 3,000 "	78	"	35 "
" 4,000 "	75	"	27 "
" 5,000 "	74	"	16 "
" 6,000 "	73	"	14 "
" 7,000 "	62	"	11 "
" 8,000 "	54	"	11 "
" 9,000 "	50	"	11 "
" 10,000 "	48	"	10 "
" 11,000 "	47	"	10 "
" 12,000 "	52	"	6 "
" 13,000 "	58	"	6 "
" 14,000 "	52	"	5 "
" 15,000 "	59	"	3 "
" 16,000 "	59	"	2 "
" 17,000 "	47	"	2 "
" 18,000 "	33	"	2 "
" 19,000 "	24	"	2 "
" 20,000 "	29	"	2 "
" 21,000 "	22	"	2 "
" 22,000 "	34	"	1 "
" 23,000 "	40	"	1 "

The law of moisture here shown is a slight increase from the earth to the height of 3000 feet, and then a slight decrease to 6000 feet, the degree of humidity being at this elevation nearly of the same value as on the ground. From 6000 to 7000 feet there is a large decrease,

and then an almost uniform decrease to 11,000 feet; it increases from 12,000 to 16,000 feet, and then decreases; the number of experiments up to 11,000 feet vary from 10 to 33; and I think good confidence may be placed in the result to this elevation, but at heights of 12,000 feet the number of experiments are evidently too small to speak with any confidence in respect to the results.

By treating the results with a clear, or a nearly clear sky, in the same way, the following results were obtained:

With a clear sky the degree of humidity on the ground was	59	from 9	experiments.
At 1,000 feet,	61	" 14	"
" 2,000 "	70	" 17	"
" 3,000 "	71	" 23	"
" 4,000 "	71	" 19	"
" 5,000 "	69	" 17	"
" 6,000 "	62	" 15	"
" 7,000 "	56	" 16	"
" 8,000 "	50	" 14	"
" 9,000 "	50	" 9	"
" 10,000 "	46	" 18	"
" 11,000 "	43	" 10	"
" 12,000 "	35	" 8	"
" 13,000 "	37	" 7	"
" 14,000 "	37	" 7	"
" 15,000 "	44	" 5	"
" 16,000 "	40	" 5	"
" 17,000 "	39	" 4	"
" 18,000 "	21	" 2	"
" 19,000 "	36	" 2	"
" 20,000 "	33	" 1	"
" 21,000 "	32	" 1	"
" 22,000 "	21	" 1	"
" 23,000 "	16	" 1	"

The law of moisture here shown is a slight increase to 1000 feet, a considerable increase between 1000 and 2000 feet, a nearly constant degree of humidity from 2000 to 5000 feet, and a gradual decrease afterwards to 12,000 feet. At greater heights the numbers are less regular. The results up to 11,000 feet are based upon experiments varying from 10 to 23, and are most likely very nearly true normal values. At heights exceeding 12,000 feet the number of experiments have varied from 1 to 8, and no general confidence can be placed in them.

By comparing the results from the two states of the sky, the degree of humidity of the air up to 1000 feet high is 15 less with a clear sky than with a cloudy; from 2000 to 5000 is from 4 to 6 less; at 6000 feet the air with a clear sky is much drier than at 5000 feet, but with a cloudy sky it is nearly of the same degree of humidity, so that the difference between the two states is large, amounting to no less than 11: the difference decreases to 0 at 9000 feet, but increases to 4 at 11,000 feet; at heights exceeding 11,000 feet the air with clear skies generally becomes very dry, but with cloudy skies frequently becomes more humid, as was to be expected from the fact of the presence of clouds at heights exceeding three and four miles.

In both states of the sky, at extreme elevations, the air becomes very dry, but, so far as my experiments go, is never free from water.

(To be continued.)

For the Journal of the Franklin Institute.

Paraselené.

At 11 o'clock, on Sunday night, the 1st inst., when the altitude of the moon was about 45°, the attention of the writer was attracted by a bright nebulus appearance, twice the apparent diameter of that luminary, in the circumference of a semi-circular corona, unusually broad, and 60° in diameter.

Although there were fleecy clouds floating in the sky at the time of observation, the writer was at once convinced of the different character of the nebulus spot observed; and his convictions as to its nature induced him to make further investigations.

A less obstructed view of the heavens than his first observation afforded, disclosed another nebulus spot, similar to that already described, in the circumference of the corona on the opposite side of the moon and equidistant therefrom.

The sky had a slightly watery appearance at the hour indicated and was shortly afterward quite overcast. The attendant phenomena were similar to those accompanying parhelion, twice witnessed by the writer.

If any of the readers of the *Journal* have witnessed phenomena similar to those herein described, or can refer the writer to any record of such, their advising him of the fact will be esteemed a favor.

C. J. W., Jr.

Germantown, April 8, 1866.

MISCELLANIES.

Cast Iron.—M. Gaudin reports that, while experimenting in an ordinary cupola furnace, by melting iron at a very high temperature, with phosphate of iron and peroxide of manganese, he succeeded in obtaining a species of iron, very hard and not forgeable, but turning well, and applicable to the manufacture of pieces which require great strength. The metal is remarkably sonorous, and might, perhaps, be applied to the casting of bells.

New Mortar. By Dr. ARTUS.—The mortar used by the Romans has, in the course of ages, set so strongly as to be equal in hardness to the stones which it was used to cement, and an analysis of it shows that this is to be attributed to the abundant formation of silicate of lime throughout the mass. The modern mortar, on the other hand, for the most part, hardens slowly, cracks while hardening, has but little adhesion, and its useful effect is simply as a bed for the proper support of the stone or brick upon its whole surface, and the consequent distribution of the pressures properly over the sustaining masses. Analysis shows little or no formation of silicates, and the carbonate, or the quicklime, (for it absorbs carbonic acid itself very slowly,) is soluble in the rain to which it is exposed, and rapidly dissolves out.

M. Artus proposes a method of preparation by which the process of silication is much favored; by which, it is said, a mortar may be prepared which becomes as hard as cement, does not crack in setting, and may even be used as a hydraulic cement under water. His process is the following: Take good slacked lime, and mix it with the utmost care with sand finely sifted. Mix the sand thus prepared with finely powdered quicklime, and stir the mixture thoroughly. During the process the mass heats, and may then be employed as mortar. Of course the mixture must be made just as it is to be used.

One part of good slacked lime was mixed with three parts of sand, and to this was added three-fourths of its weight of finely powdered quicklime. The mortar thus made was used in a foundation wall, and in four days had become so hard that a piece of sharp iron would not attack it. In two months it had become as hard as the stones of the wall. (*Ann. du Genie Civil, Zeitung des Ver. Deutsch, Eisenbahn-Verwalt.*)

Would it not be worth while to try this for laying the bricks of our chimnies, which are so rapidly destroyed and rendered dangerous by the gases from burning anthracite?

Detection of Adulteration of Oils.—We find, in the *Bulletin de la Société Industrielle de Mulhouse*, a communication from M. Nicklès, to which we call attention, as it may, when properly studied, be of importance in detecting the adulteration of oils, now so difficult to ascertain.

It appears that the sweet oil of almonds is almost always found adulterated by a cheaper material, known as the oil of apricots, and to detect this falsification M. Nicklès proposes the following mode: Take about 10 grammes of the suspected oil, (the gramme is about 15½ grains,) and shake it with about 1½ grammes of slacked lime, (in powder.) Heat it in a water bath, taking the precaution not to raise the heat above 100° C., (212° Fahr.) Filter while warm. If the oil contains as much as 1 per cent. of the impurity, a cloudiness will be seen as the filtrate cools, disappearing again on the renewal of the heat. By suffering the oil to cool to the ordinary temperature, this cloud may be separated by filtration, and will be found to be a species of emulsion, formed by the oil of apricots with the lime. It is fusible by the heat of the water bath, and is then a limpid liquid, lighter than water, and congealing by cold, soluble in warm oils, but separable by filtration when cold, soluble in sulphuret of carbon, decomposable by mineral acids, aided by a gentle heat.

M. Nicklès goes on to show that olive oil, (sweet oil,) colza oil, as well as the sweet oil of almonds, do not produce this emulsion with lime; while hemp seed, poppy, walnut, (English walnut,) and flax seed oils give it, more or less. Cotton seed oil gives very little, but castor oil a very thick, coagulum.

Now, as a great deal of the material which is sold here as olive oil is really little more than lard oil, it would be worth while to see whether this falsification could not be detected in this simple way.

M. Nicklès also calls attention to the unfitness of sweet almond oil for lubricating watch-work, for although when pure it produces no action upon the brass, yet it sooner or later hardens, never having been freed from its drying quality.

—

Lead Poisoning.—A somewhat curious, and certainly very interesting case of poisoning by lead has just occurred in the Walkill Valley, in New York State. A miller of that valley, renowned for the quality of his flour, and correspondingly pressed to furnish the supply demanded, had mended an old pair of stones by running metallic lead into the cavities. The consequences were fearful. Over two hundred cases of lead poison made their appearance among his customers, some of which were fatal, and some resulted in permanent paralysis of the limbs. It is said that the particles of lead could easily be detected by the microscope in the flour. It would also appear that this is the usual method of repairing worn mill stones. Of course, the processes of fermentation and baking of the flour convert the lead into the carbonate or white lead.

Is it not time that the millers were furnished with an available substitute for the coarse sandstone or conglomerate, which is still universally used in grinding flour, and which, by their irregular wear, give life to such methods of mending?

—

New Flying Ship.—We find, in the New York papers, the notice of a new flying apparatus, constructed by Dr. Solomon Andrews, which, we suppose and hope, is the one which was reported to be in process of construction by the U. S. government. Dr. Andrews' apparatus is an oblong ("lemon-shaped") balloon; along which, both at top and bottom, a deep groove is made by means of a stout leathern strap passing around it, and furnished with the requisite braces for slackening or tightening it. This is to serve as a keel to hold the vessel to her course. The method of progression is by elevating or depressing the forward end on the principle of a kite or a bird when sailing, and the inventor is doubtless right in his anticipation that in this way it may be made to go against the wind, provided it be not too violent. The preliminary trials do not seem to have been actually successful, although results were obtained which seem to have encouraged the inventor. The fault of the failures is laid upon the rudder. The great difficulty, we apprehend, will be found in the leeway which such a vessel must make with the wind abeam, an action against which the most powerful birds find it difficult and frequently impossible to sustain themselves.

We find, in the *Cosmos* of Paris, a curious statement, taken from a newspaper of Rouen, of the sudden appearance at Houlme (Seine-Inferieme) of a flying ship, which stopped for a supply of coal. The statement of the aëronauts was, that their boat was devised and constructed by Sir George Matthews of Darlington, England, who left that place on the 27th of March, accompanied by MM. Barckley and William Thompson, professors in the "School of Oxford." (The University?) First vis-

iting Scotland, they then steered to the north-east and crossed the North Sea in the direction of the island of Heligoland, (which is south of east from any point of Scotland,) over which they passed on the 29th, moving towards Hanover with the intention of going to St. Petersburg, but being baffled by heavy fogs (!) they changed their route, and, after various perigrinations over Germany, returned towards England, and arrived at Houlme on the 31st, where they stopped, at a height of 30 feet, for a supply of coal. The travelers refused to explain the construction of their machine, or to allow it to be examined, but the correspondent describes it as an elongated ellipsoid of very thin galvanized sheet iron, with several gas receivers, and driven by a small engine, (which the smell indicated to be an ether engine,) by means of two screws.

—

Coal-bricks.—Our English cousins are getting to be seriously anxious about the endurance of their coal-fields, which has been authoritatively pronounced to be a question, not of centuries, but of years; and a distinguished gentleman of our city, whose position gives him excellent opportunities of knowing, and whose capacity of judging gives great weight to his opinion, is said to have predicted that in a few generations our anthracite would be a luxury for the rich, and an impossibility for the arts. In view of such possibilities, economy becomes a duty, and we recommend to the notice of all interested a very elaborate memoir by M. Gruner upon the methods in use for utilizing the coal waste by conversion into bricks, by means of tar or other cheap materials. M. Gruner, after an introduction devoted to the history of these methods, proceeds to discuss the subject at large, describing the different forms of apparatus used, pointing out their merits and defects, and explaining the whole method of the process. The memoir is too long to be transferred to our pages, and, from its nature, cannot be condensed, but we recommend it to all who are disposed to look into the subject as being apparently an exhaustive treatise. It will be found in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* for October, 1865.

—

Cheap Electric Battery. By M. GERARDIN, Acad. of Sciences, Paris. —M. Gerardin proposes to obtain a battery of feeble tension, but considerable quantity and cheap, by substituting in the Bunsen battery chippings of wrought or cast iron in place of zinc. An iron plate in contact with them serves as a conductor; the exciting liquid is ordinary water. In the porous cell, the Bunsen carbon, made of gas coke pulverised and cemented by paraffine, by M. Carlier's process, is immersed in a solution of perchloride of iron, to which some aqua regia is added. This pile can be made of large dimensions; and the proposer states that large quantities of electricity can be obtained from it at a very small price.

—

Aurora Borealis.—M. E. Renou has collected and discussed all the available records of the appearance of this meteor, for the purpose of

developing, if possible, the period of its maximum and minimum occurrence. The yearly period is that established by Mairan, viz: two maxima near the equinoxes, of which the fall maximum is the principal; and two minima, corresponding to the solstices, that of the summer being the most marked. The secular period presents in Europe a well marked maximum, from 1716 to 1780, the period being probably about 196 years. In America, the period would seem to be alternate with that in Europe. It is to be remarked, that as the phenomenon appears to be almost continuous in higher northern latitudes, the periodicity would refer only to the extent to which the appearance is visible.—*Acad. of Sciences, Paris.*

—

Mortars for Marine Constructions.—M. Poirel called the attention of the Academy of Sciences of Paris, to the great importance of the question, "What mortars could be most safely employed for artificial blocks for the foundations of marine constructions?" He states, as the result of his own experience in constructions at Leghorn and at Algiers, that the only material upon which full reliance can be placed, is the pozzuolana from Rome, sifted through metallic bolters, and combined with fat lime slacked with two and a half times its weight of water. One part of this hydrate is mixed with two parts of pure pozzuolana, when the beton is to be immersed at once; or with one part of pozzuolana and one of sea-sand, where it can be dried before immersion. He states, that in regard to the difference of opinion between M. Vicat and M. Minard, as to the durability of betons thus made with Italian pozzuolana, experience has shown that M. Minard was correct in affirming this durability; and that the laboratory experiments of M. Vicat, by which it was shown that such materials could not withstand the action of the sulphate of magnesia which exists in sea-water, were inconclusive, because, in practice, the beton is protected by a calcareous deposit, which forms on its surfaces, and by the growth of sea-weed by which it is covered. He condemns the use of artificial Roman cement, whether of French or English origin, and predicts the rapid destruction of marine works constructed with them; and states that in certain works executed by him in Turkey, in 1847 and 1848, he used a natural pozzuolana from the Santorin Island, which have stood so far very well, although the experiment has not yet lasted long enough to be entirely reliable.

—

The Secular Acceleration of the Motion of the Moon.—La Place showed that the change of eccentricity of the earth's orbit must produce a corresponding acceleration in the moon's motion, and the amount of this change was calculated by him, by Plana, Damoiseau, and by Hansen, all in good accordance with each other, and all giving a value which agreed very well with ancient observations of eclipses. But Mr. Adams, in reviewing this subject, thought he found an error in the formulas, which reduced this acceleration about one-half, and his results having been confirmed by M. Delaunay and others, a vigorous controversy arose, which appears to be now finally settled in favor

of Mr. Adams and Delaunay, M. Hansen, the last eminent conservative, limping out of the matter in rather a lame manner. But the ancient eclipse observations must be satisfied, and the new co-efficient upsets our chronologies, and represents great admirals as sailing their ships on the sands of the Lybian Desert. Some other cause must, therefore, be looked for to give the additional six seconds per century of acceleration wanted, and fortunately it is in modern science that the scriptural maxim, "Seek and ye shall find," is infallibly fulfilled. M. Delaunay has consequently come upon the discovery that La Place was wrong in establishing the invariability of the earth's rotation on its axis; that, in fact, the moon, by raising the tides, and not doing it quickly enough, is constantly producing a friction on the bottom of the ocean, which is slowly but surely bringing the earth to rest. But M. Delaunay calculated without the geologists. As the earth, according to these, is continually shrinking, "like a roasted apple while it cools," the rotation ought to become more rapid, and these desirable six seconds be absorbed. So that we hail the new suggestion of M. Dufour, that these six seconds are due to the increase of mass of the earth by the showers of meteors upon it, and he shows that, supposing the average density of these meteors to be two-thirds of that of the earth, (3·67,) 110 cubic kilometers, or about 264 cubic miles per year, would be required, which, as M. Dufour remarks, is nothing impossible. M. Dufour's theory has also the advantage of showing that the earth is increasing in importance in the system, which is flattering to our vanity.

Since writing the above, Mr. Airy, the royal astronomer of Great Britain, fully endorses M. Delaunay's views, and his endorsement will carry the more weight since it is evident that it was only towards the close of the investigation that he was led to concur, his first verdict being evidently "not proved." Prof. Gurld also writes to remind Mr. Airy that the same result was reached by Mr. Ferrel, in a paper published in the *Astronomical Journal*, (Boston,) in 1853, where it was shown that the effect of the moon, in one century, would be a retardation of the earth's equator of about 37·5 miles in a century, and that, adding the effect of the solar tide, the total retardation should be about 44·5 miles, which retardation would be equivalent to an apparent acceleration of the moon's motion of 84″ per century. And, in conclusion, the author calculates that, to counteract this acceleration, (nothing like which had then been observed,) "there is required a contraction of about 1·017 feet in the earth's radius during a century, upon the hypothesis of an equal contraction throughout the mass."

—

Water-proof Packing Paper.—The following is a German recipe: Dissolve 680·4 grammes (about 1·82 lb.) of white soap in a quart of water. In another quart of water, dissolve 1·82 oz., troy, of gum arabic, and 5·5 ozs. glue. Mix the two solutions, warm them, and soak the paper in the liquid. Pass it between rollers, or simply hang it up to drip, and then only at a gentle temperature.

Chlorophylle.—M. Fremy, who, some time ago, succeeded in decomposing the green coloring matter of leaves into a yellow and a blue coloring matter, has carried his investigations further, and shows that the true matter is an acid combining with bases, while the yellow is neutral. The combination of the two suggests analogy with fats which are also combinations of a peculiar organic acid with glycerine, a body which, although playing the part of a base in this combination, is neutral in its general behavior. M. Fremy, however, does not believe that the chlorophylle, in its living condition, is a compound of this nature, but considers it as a very unstable body, breaking up, by the action of the reagents, into these two substances which he has succeeded in obtaining. As we learn that the blue (phyllocyanic acid) easily modifies its color by dilution, or by reaction, assuming olive-green, purple, or bright red tints, the splendid coloring of our autumn forests becomes easy of explanation.

Substitute for the Nicol's Prism.—MM. Hartnack and Prazmowski give, in the *Annales de Chémié et de Physique*, their investigation of the Nicol's prism, and their method of remedying its defects, which are the limited field of vision and the inconvenient length. They propose to cut a prism of calcspar, so that the diagonal section shall be perpendicular to the optical axis of the spar, and cement the parts by linseed oil. This prism is shorter than the Nicol in the ratio of 2 to 3, and may be used as an analyzer, with a compound microscope, without limiting the field and without inconvenience to the observer.

New Magnets.—Mr. Griess has observed that the turnings of iron and steel, and especially those long shavings which come from the lathe, are strongly magnetic. Their magnetism is permanent. The spiral turnings of wrought iron show this remarkable property in the highest degree. He finds that the end at which the tool commenced is a south pole, the other extremity being, of course, the north. The direction of the spiral is also said to exercise an influence on the intensity of the magnetism produced.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, June 20, 1866.

The meeting was called to order with the Vice-President, Professor Fairman Rogers, in the chair. The minutes of the last meeting were read and approved.

The Board of Managers presented their minutes, and reported that at their meeting on the 13th inst. they received donations to the library from the Royal Astronomical Society, the Chemical Society, the Institute of Actuaries, the Statistical Society, and the Society of Arts, London; La Société d'Encouragement pour l'Industrie Nationale, Paris, France; the Canadian Institute, Toronto, Canada; the Chamber of Commerce, New York; the Managers of the State Luna-

tic Asylum, Utica, New York; Thomas Gaffield, Boston, Massachusetts; the Odd Fellows' Library Association, San Francisco, California; and Edward Parrish, Esq., Prof. John F. Frazer, Thomas P. James, Esq., and John W. Nystrom, Esq., Philadelphia.

Four gentlemen were elected members of the Institute.

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion reported progress.

The monthly Report of the Resident Secretary on Novelties in Science and Art was then read as follows:

Secretary's Report.

Engineering Works.—Water Supply of Paris.—We find an excellent article upon the above subject in the *Practical Mechanics' Journal* for May, from which it appears that up to the present time the supply of this very important article has always been deficient, and, though constantly increasing, has never caught up with the increasing demand. Thus, in 1550 it was 44,020 gallons per day, or less than one-fifth gallon per inhabitant. Several changes were made during the next century, by which the quantity was increased to 396,180 gallons per day, or ·66 gallons per inhabitant, an amount, however, absurdly inadequate, especially when it is remembered that this included ornamental fountains and the like. In 1782 the supply was increased by the works at Chaillot, which, however, drew their material from under the very sewers, and in the drought of 1856, when this afforded five-sixths of the whole supply to the city, it contained, as was proved by analysis, one-forty-fourth of sewage water.

These works raised the supply to 1,760,800 gallons per day, or 3·08 gallons per inhabitant.

In 1822 the canal of the Ourcq, 60 miles long, and used also for purposes of navigation, was finished, and, with seven private works pumping from the Seine, together with the artesian wells of Grenelle and Passy, raised the supply to 46,000,900 gallons per day, which includes, however, the quantity required by the extensive ornamental water-works at the Bois de Boulogne, &c., and was found very inadequate, especially during the hot weather.

In October, 1865, a fresh supply of pure and excellent water was brought in by an aqueduct from the Dhuis, amounting to 5,722,600 gallons per day. By this and the increased development of the old sources, it is estimated that 75,714,400 gallons per day may be obtained, which will cover the existing demands, which are for 70,211,900 gallons, while works are shortly to be undertaken for carrying the waters of the Vanne to reservoirs at Montrouge. The supply will then cover the anticipated increase in demand, (about 22,230,000 gallons,) and will amount to 18 gallons of spring water per inhabitant, with 26,412,000 gallons for flushing sewers, &c.

To receive the waters of the Dhuis, enormous crypts have been constructed at Menilmontant, capable of containing nearly 30,000,000 gallons. The first of these constructed has a capacity of 22,010,000

gallons. Its arches are 18·4 feet high, supported by 590 piers, 19·7 feet apart. It is to be covered with sod, and the water flows into it over a mass of rock-work, and amid beautiful shrubbery. It was built upon marly ground, which necessitated deep foundations, which suggested the idea of excavating under it for a second reservoir. This has been accomplished, and the lower crypt has a capacity of 6,823,100 gallons. Its arches are supported by 240 piers of the most massive structure. During the late visit of the municipal authorities, before the water was admitted, these cyclopean vaults were illuminated by the electric light, with the most striking effect. The cost of these reservoirs is about $720,000.

Hydraulic Lift Graving Docks.—A paper was read on this subject before the London Institution of Civil Engineers by Mr. Edwin Clark. The vessel to be docked in this manner is floated into the lifting pit, at the bottom of which has been placed a large iron pontoon, properly connected with a series of hydraulic lifts surrounding the pit. By these the pontoon and ship are raised until the water has run out of the former through appropriate valves, when the whole will float with a draft of but 3 or 4 feet, and may be moored in a shallow water space adjoining the lift, and wherever most convenient for work.

Such a plan was adopted by the Thames Graving Dock Company in their works adjacent to the Victoria Docks. The lifting pit was 27 feet deep, 60 feet wide, by 400 feet in length. Sixteen presses were placed on each side, with iron girders, 65 feet long, connecting them in pairs across the pit. Attached to this were 16 acres of shallow water space, 6 feet deep, for floating the pontoons, &c., when raised. This was divided into 8 pontoon berths by jetties for workshops. Total cost $127,640. Number of vessels lifted last year 1055. Aggregate tonnage 712,380 tons.

A Large Iron Suspension Bridge is about to be constructed over the Moldan at Prague, on Mr. Ordishe's rigid principle. It will consist of three spans, the centre one 476 feet long, the others 172 feet. The roadway consists of two wrought iron web girders, 6 feet 10 inches deep, with T-irons along the middle, to give lateral stiffness. The web will be punched out in an ornamental pattern above the actual roadway. These girders are supported by a series of straight inclined bars, which are themselves held in their straight position by guys from curved chains or wire ropes above.

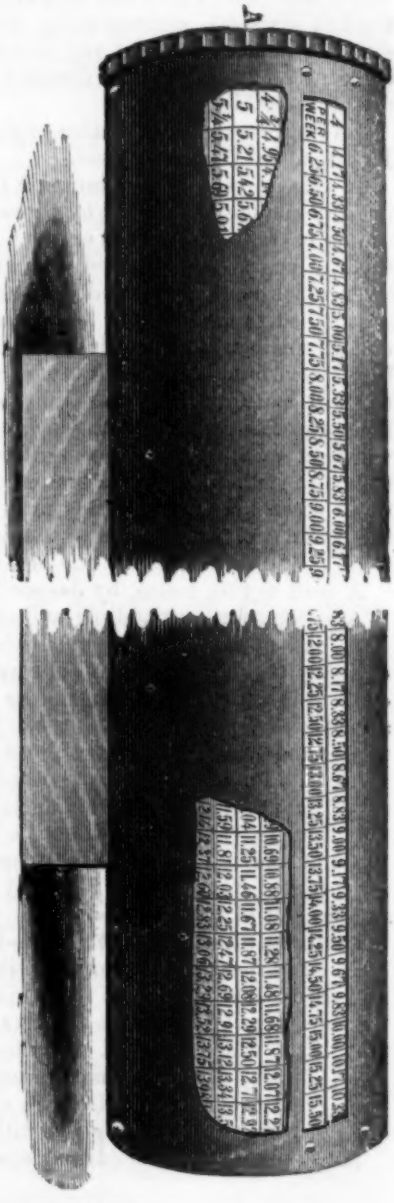
An iron girder bridge, 1524 feet long, designed by James Laurie of Hartford, Conn., has lately been completed over the Connecticut River, on the Hartford and New Haven Railroad. This structure was erected to replace one of wood, and was substituted piece-meal for the latter, while that was in use, with trains running on the average every 30 minutes during the day, and with only a single track.

The iron work was constructed by Wm. Fairbairn & Co., Manchester, and the London Engineering and Iron Ship-building Co., the press of work for the government at that time preventing any of the American manufacturers from undertaking the contract. There are twelve spans of 88½ feet, and one of 177 feet.

There were then exhibited various models and improvements in apparatus, as follows:

The improved calculator by C. W. Peale.

By the use of this instrument the various causes of error heretofore existing in the making-up of pay-rolls are entirely avoided. It consists of a cylinder, (see cut,) on the surface of which is arranged a calculated table; the left-hand column contains the number of days and fractions of days to be calculated, namely, 1, 1¼, 1½ days, and so on, for any number of days, to suit, for weekly, semi-monthly, and monthly payments. This cylinder is enclosed in a zinc case, and revolves therein on pins having a bearing in the ends of the case. It is easily moved by a milled head at the left end, and the whole is neatly mounted on a walnut base. Running nearly the entire length of the case is an opening sufficiently wide to expose but one row of figures at a time. Immediately below this opening is placed, on the outside of the case, a row of figures denoting the several rates of wages, from the lowest to the highest ordinarily paid. The operation of this instrument can be readily understood by presenting an example, as follows:



To find the amount of wages necessary to be paid for 9¾ days at the rate of $12·75 per week, or $2·12½ per day, turn the cylinder by means of the milled head at the left end, until the figures 9¾, on the left-hand column, appear to view; then above the figures $12·75, denoting the rate of wages, on the outside of the case, will be found $20·72, which is the amount to be paid.

The discount and interest calculator, also invented by C. W. Peale. This instrument consists of a shallow box, 11 by 6½ inches, provided with a band, passing over rollers within it; upon this band is the table of the amounts of discounts, also the days to run. Upon four slides, which move backwards and forwards under the cover of the box, are marked divisions, corresponding to units, tens, hundreds, and thousands, which, when set at any division, expose, through openings in the centre of the box, the discount corresponding to the time at the top of the table.

An improvement in traction engines and locomotives, by Theodore Krausch, was then exhibited.

In this, the object is to increase the adhesion of the locomotive during any change in velocity by throwing part of the weight of the preceding or following trucks or cars upon the engine. To accomplish this the engine is connected with the truck or car by a long bar or lever which rests on a rounded block as a fulcrum near the end, which is attached to the frame of the locomotive by a vertical link; the other end of this bar is attached to the truck. In its normal position the bar is horizontal and the link vertical, but any pull or push upon the bar will cause the link to incline, so bringing down that end of the lever and raising the other, which, being attached to the car or truck, will tend to lift it, so throwing its weight upon the engine. By this means at starting or on up grades when the cars pull, or in breaking up or down grades where they push upon the engine, this action gives the latter greater adhesion to the rails and will enable a light engine to do the work of a heavy one just where this is required.

A fruit drying house, by Jasper Billings.

A water door for puddling and other furnaces.

A gas purchase-tongs, by Richard Cox. This differs from the ordinary tool in two respects: First, it has but one handle; and second, it is adjustible in its grip, so that two tongs would suffice for all sizes of pipe in general use. The lower or concave jaw of this tool is short, and terminates above in a swiveled nut, through which passes the long handle of the other jaw, whose end or griping extremity is connected by a revolving joint with the rest of the handle, so that this last can turn in the nut of the lower jaw, changing the distance of the two without otherwise disturbing the upper jaw, which is prevented from turning round by a projection, which fits in a longitudinal slot of the lower jaw.

Utilization of Coal Waste.—In the October number of the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, we find an excellent paper on the various plans which have been adopted for consolidating coal dust and like "waste," which forms so large a part of the whole material extracted from the mine.

The history of inventions and improvements in this process is given with great completeness, from an early period, and the practical results of various plans are given with precision.

Many plans for consolidating coal dust without cement have been

tried, and the accomplishment of this end is very desirable, but has not as yet been attained. Thus, the bricks prepared according to the plan of Evrard, by mere pressure, burn well, but will not bear transportation.

The process of Bessemer, in which the coal is heated almost to redness and then compressed, is too expensive and wasteful, while in that of M. Baroilier, where the coal is compressed first and baked afterwards, the cost for handling is considerable, and the "plant" required very expensive.

Among cements, the cheapest is potter's clay, the most usual, coal tar and its derivative solid or fluid pitch.

The coal selected for treatment should be friable, semi-bituminous, or a mixture of "hard" and soft, of short flame, well washed from earthy matter. As little cement as possible should be used, and this result may be best secured by thorough mixture and heating. The pressure applied should reach about 1 ton to 1½ tons per square inch, and the bricks should be thin. Thus a brick containing 18 to 20 lbs. should be about 4 inches thick. To effect the compression on the large scale, the best machine is that of Révoillier, in which a moving circular table carrying moulds is combined with an hydraulic press acting quickly, by means of a reservoir under pressure. Working on a small scale, the machine of MM. David and Mazeline, which acts by tangential wheels, will be efficient.

In France, 18 or 20 establishments are engaged in this manufacture, and produce yearly about 500,000 tons. In Belgium seven manufactories produce 400,000 tons.

In the above-mentioned journal for November we also notice an excellent article on the subject of steam paving machines, from which it appears that engines running on heavy rollers, and self-moving, which execute their work by simply going over the ground, are and have been employed with marked economy and success in the various concrete and macadamized pavements of Paris.

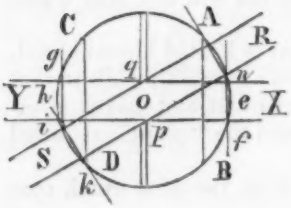
PHYSICS.—The New Photographic Lens invented by Joseph Zentmayer of this city, is of the greatest interest, not only in a practical sense, because it is a most excellent and efficient instrument, which can be constructed at less than half the cost of any other equally good combination, and possesses other like advantages of lightness, compactness, adjustability, &c., which will be more fully stated hereafter; but in a scientific point of view also, because it involves new principles and new applications of optical laws.

The theory of this lens may be best explained by the following progressive illustrations:

Let A B and C D represent two plano-convex lenses exactly alike in every respect, so placed that their outer surfaces form parts of the imaginary sphere A C D B, and with a small opening $p\,q$ in a central diaphragm. Neglecting for a moment the bending of rays by refraction, we see that the only rays which can pass the diaphragm are those which come normally upon the outer surface, as X Y and R S. Supposing sections to be made in the direction of the chords $n\,f$, $g\,i$,

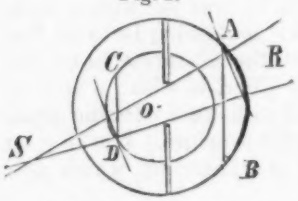
we see that the ray X Y will be subjected to the action of two small lenses, *n e f*, *g h i*, (limited by the size of the diaphragm,) and two blocks of parallel glass. The aberration, spherical and chromatic, may therefore be regarded as that only which is due to two such extremely minute lenses.

Fig. 1.



Turning again to the ray R S, and supposing similar sections, A *n* and *i k*, we have the ray again acted upon by two small lenses like the first, but in this case traversing two prisms. As, however, these are exactly equal and opposite, they will correct each other, and the aberration in this, as in the former case, will be such only as is due to the two small lenses. We are here speaking, it must be remembered, only with the purpose of explaining a general principle, and without regard to accuracies of detail which would confuse the subject, as we think.

Fig. 2.

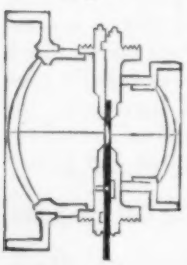


In this preliminary illustration we have made no account of the *deflection* produced by the first prism, nor of the *concentration* due to the little lens. To meet the first, the diaphragm is moved a little forward from the centre, O, and for the second, in place of the large lens, C D, a smaller one of shorter radius is so placed that its outer surface is practically concentric with that of A B. (See Fig. 2.)

The converged ray thus finds in C D an equivalent opposite prism to that it traversed in A B, and is only subject to the aberrations due to the two small lenses, now of *unequal* curve.

Thus far the general principle by which a lens of very small aberration may be made with only one kind of glass, or without *correction*, has been treated.

Fig. 3.



Such a combination, however, as that last described would be of little value because of its very short focus and want of flatness in field. To remedy these difficulties, in place of plano-convex, meniscus lenses are used, (as shown in Fig. 3,) whose inner curves are to their outer ones as 13 is to 12. The curves of the two lenses are to each other as 3 to 2 in all cases. Any variety of combinations and series of focal lengths might be constructed on the above principle, but the plan adopted is as follows: The most complete set consists of six lenses, whose focal lengths are—

I.	5·333 inches.	IV.	18· inches.
II.	8· "	V.	27· "
III.	12· "	VI.	40·5 "

These may all be successively arranged in the same mounting, giving

combinations with focal lengths and circular fields at 90° as follows:

Lenses I. and II.	give a focal length of	3·55	inches	and field	7	inches	diameter.
" II. " III.	"	"	5·33	"	"	10½	"	"
" III. " IV.	"	"	8·	"	"	16	"	"
" IV. " V.	"	"	12·	"	"	24	"	"
" V. " VI.	"	"	18·	"	"	36	"	"

Thus, with six lenses and one mounting, five different instruments may be successively adjusted in as many minutes, the mounting being so arranged as to fit into the camera either way. To pass from one focal length to the next longer in the series, it is only necessary to take out the smaller lens and put in its place the second size above. Thus, to change 8 inches into 12, lens No. III. is replaced by No. V., and the mounting reversed. A little shutter, close to the central diaphragm, serves for "exposing" in place of a cap, and a diaphragm plate is arranged with three holes for each combination, a large one for focusing, a middle size for quick work, and a small one for fine and difficult work, for it is one of the merits of this lens that a large stop may be used for focusing, and a small one thrown in for the exposure with not only good but the very best effect.

In these lenses the visual and actinic focii appear to coincide, so that no adjustment after focusing is needed. The field is very equally illuminated, because no doubt, as will be seen from Fig. 1, the marginal rays, as well as the central, are normal to the first surface, and do not lose unequally by reflection. The depth of focus is most remarkable, and for quickness of work surpasses that of any like instrument. Excellent views have been taken in 15 seconds on a bright, and 30 seconds on a dark day.

Mr. Coleman Sellers here remarked as follows:

There are some facts in connexion with the history of this invention which I think will be of interest to those present. Some two years since I had many conversations with Mr. Zentmayer on the subject of the globe lens, and of such lenses as were constructed in a similar manner, and, at that time, he expressed to me his opinion that in such a combination, whose outer surface was a sphere, and which had a central stop, all correction by use of two kinds of glass in the separate lenses was unnecessary, and that a combination might be constructed, consisting of two deep meniscus lenses, which would possess all, and more than all, the merits of the globe lens, and be in addition, much cheaper, lighter, and characterized by many other peculiar advantages.

The theoretical view of the subject, and the proposed structure of the lens, Mr. Zentmayer explained to me at that time by drawings which correspond with those shown this evening, and with the instrument itself, as you now see it before you. It is a matter of peculiar interest and redounding to the credit of the inventor that this instrument was thus the result, not of chance discovery or accidental observation, but of thorough and accurate scientific knowledge judiciously applied to the development of a definite object.

At the time already mentioned, I strongly urged Mr. Zentmayer to construct a lens according to his plan, and secure a patent on the

same, and, after such delay as extensive and active business relations rendered unavoidable, this was done, and the patent, in fact, ordered to issue, when, before the papers were posted, though actually directed, an application was received from Mr. Steinheil, and an "interference" declared by the authorities of the Patent Office. On trial, however, Mr. Zentmayer conclusively proved "priority," and his patent was finally secured. The resemblance between these combinations of Zentmayer and of Steinheil is confined, however, to the fact that both use two meniscus lenses of one kind of glass and a central stop. While the principles on which they are based and their modes of construction are essentially different. Thus, in Steinheil's combination, the outer curves of the lenses are not concentric with each other, and, with the diaphragm and the rays which pass the latter, are not normal to the surface; the two lenses used are not of different curves, nor do they admit of any change by substitution. The stop used is much smaller, and the time of exposure therefore greater, and, what is most important, there is no coincidence of the visual and actinic focii, and adjustment after focusing is therefore required.

The diagrams required to illustrate the preceding description were drawn upon glass with Japanese india ink, and thrown upon a screen 12 feet square, by a large lantern, with so much distinctness, that two large gas burners in front of the screen, burning at full head, did not sensibly impair the effect and allowed the Secretary to refer to his notes with facility, and to point out the various parts, with a rod, as would be done were the image an actual drawing upon the screen.

A Series of Drawings on Glass, illustrating the account of a remarkable *sun-spot* lately published by Mr. Howlett, were then shown by projection in the same manner. These drawings were made in a manner suggested by Mr. Joseph Wilson, C. E., by first washing on thin india ink and then working over with thick ink in a dry brush, and, lastly, going over certain parts by stippling and fine scratching with a steel point. The pictures so obtained were remarkably delicate and accurate.

A Series of large Photographs (6 inches in diameter) **of Microscopic Objects**, made by Dr. Robert Griffith with lenses of ordinary description, but provided with a central diaphragm, were then projected in like manner and showed admirable flatness of field and sharpness of definition.

An Arrangement of Glass Tanks, by which many physical and chemical experiments may be exhibited on a large scale, with the lantern, was then shown. To construct these, all that is required is a few pieces of moderately thick sheet glass, some strips of thick rubber $\frac{1}{2}$ inch to 1 inch, and some simple clamps. The strip of rubber is bent so as to form three sides of a rectangle, being cut partly through at the corners, and a plate of glass being placed on each side, the clamps are adjusted so as to hold all together. The tanks thus prepared are generally about $\frac{1}{2}$ inch thick inside, and 4 by 6 inches in the other direction. The backs of the clamps being flat, the tank stands very well on the two lower ones. These tanks are very easily made, cost

little, are readily cleaned, and admit of numerous modifications. The simple tank answers to show in the lantern the action on light of variously refracting liquids when mingling, and their motions produced by differences in density with a very impressive effect. Thus, a solution of muriate of tin, run by a pipette into a tank of water, will develop on the screen something suggestive of a submarine volcano in full eruption.

The same arrangement serves to exhibit many chemical reactions with striking characteristics. Thus, a little sulphate of copper being dissolved in the tank, and weak ammonia being run in, a mass of black clouds are first seen rolling and tumbling upon the screen, then gradually melting away into a clear sky-blue.

By placing one solution in the tank, and another in a test-tube plunged therein, the colors of both before combination may be noted; then, by upsetting the test-tube with a glass rod, the reaction and consequent change of color is beautifully displayed. Even delicate experiments conducted in test-tubes may thus be exhibited to large audiences by plunging the tubes in one of these tanks containing clear water when the refracting action of the round tube is corrected.

The larger sort of aquatic insects and small fish make very interesting magic lantern objects in these tanks. With a wet cork-borer, holes may be readily pierced in the rubber sides of these tanks and glass tubes introduced, by which, connexions being made for overflow, outlet, and fresh water supply, a series of changes may be conducted in the same tank with great rapidity and ease without removing it. To use these tanks with the ordinary lantern it is only necessary to arrange a separate support for the object-glass, so as to leave a clear space in front of the condensers where a block or little shelf to support the tanks may be placed. The decomposition of water by galvanic action, formation of metallic crystalline vegetation by the same, &c., may be readily shown. These various arrangements have been used by the Secretary, during the last winter, with the most satisfactory results.

The Yellow Light from Soda Glass mentioned in the last report, is found by the Secretary to answer very well, when used in the gas polariscope, to show the vast increase in number of rings developed by sections of crystals when monochromatic is substituted for white light. The adjustments are first made with the lime cylinder, the glass is then substituted and slightly lowered, when, in place of the six or seven rings before seen, we find a great number covering the whole screen.

The Spectrum of Sirius, according to the observations of Father Secchi, shows between the extreme red and the line A a number (28) of equidistant bands.

The Spectrum of α Orionis has lately lost a group of fine lines in the orange near the yellow. This corresponds with the change of color in this star, which varies very irregularly both in the color and intensity of its light.

The great Nebula in Orion, lately proved by spectrum analysis

to be gaseous, appears, from some observations by Mr. T. W. Webb, to give evidence of change in form.

It is worthy of note that all the drawings of this body, made by different observers, have been decidedly unlike. (See Mo. Notices of Roy. Astr. Soc., 1866, page 208.)

Enlargements of Professor Piazzi Smyth's photographs of the pyramids and their environs, from original negatives one inch square, were exhibited by projection on the screen at a late meeting of the Edinburgh Photographic Society.

A Kaleidoscope for the Magic Lantern, presented by James Queen & Co., was exhibited with various objects and found to give a field of remarkably even illumination and beautiful effect.

A new Galvanic Battery is proposed by M. Gerardin. The outer cell is to be filled with iron turnings having a strip of sheet iron for a pole, the liquid, water. The inner cell to contain a carbon element plunged in a mixture of perchloride of iron and aqua-regia. (*Comptes Rendus*, page 700.) We do not see how the connexion between the various pieces of iron turnings is to be maintained. Where amalgamated zinc is used, this is accomplished by an excess of mercury.

Transparent Paper may be prepared by the use of copal varnish diluted with its own bulk of turpentine and well filtered through cotton. The paper should be stretched on a frame and varnished on both sides while held near a hot iron plate, then dried for a week.

A Process for Coating Iron with Copper is given in the *Journal of the Society of Arts*, with many absurd mistakes. A correct account, *i. e.*, the original report by M. Payen, will be found in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale.*

CHEMISTRY.—The Removal of Hypo-sulphite of Soda from photographic prints by placing them, for a few moments, in water containing a small per centage of deutoxide of hydrogen, is stated by the editor of the *British Journal of Photography* to be accomplished with great ease and completeness, and thus to remove the danger of deterioration by which these pictures are now beset.

Mr. Coleman Sellers remarked that he regarded the fading of prints, not as the result of hypo-sulphite of soda left in the paper, for he had known prints, purposely charged with this salt, which absolutely refused to fade, but as occasioned by sulphide of silver. This salt also might be removed by the oxygenated water, but as yet this was a matter only of theory which time must settle.

It is stated on the authority of Schonbein that HO_2 may be prepared by shaking in a bottle with air, powder of amalgamated zinc, and water.

The Defecation of Sugar by hydrofluoric acid, which is afterwards removed by lime, has been tried on the large scale with good effect at the Fridens-Aw factory, as is stated in the *Journal of the Society of Arts.*

A new Filter for River Water, which is stated to remove the soluble as well as insoluble impurities, is stated by Mr. T. Spencer to be found in a mixture of oxide of iron and carbon. This may be best prepared by heating magnetic oxide or red oligist with wood saw-dust.

The *Medical Times* suggests the addition of a little permanganate of potash, before filtering to oxidize organic matter.

In the *Comptes Rendus* we find a note by M. Tellier on the manufacture of methylic ether and its application to the production of cold. When the committee, to whom this matter has been referred, make their report, we shall know something about the curious complication of blunders cited under the head of "Freezing Machines" in last month's report.

Platinum may be purified and also rendered more malleable by heating with double chloride of magnesium and ammonium.

This same metal is deposited so as to resist the solvent action of hot sulphuric acid by a new process carried on by J. B. Thompson of Manchester, England. M. Scheurer-Kestner of Thann, found that each 1000 kilo. (2204 lbs.) of acid carried away about 2 grms. (30·8 grains) of platinum in the ordinary stills, and as much as 5 grms. (77·2 grains) if much nitric acid was present. A little sulphate of ammonia added to the acid prevented this waste, and platinum containing iridium suffered less than the pure metal.

An Amalgam of Magnesium may be formed if the mercury is heated, and will oxidize with wonderful rapidity, decomposing cold water with copious evolution of hydrogen, even when the amount of magnesium present is but a small per centage.

Bichromate of ammonia heated in the air undergoes a slow combustion, and is converted into a largely increased bulk of sesquioxide of chromium, having the shape and color of green tea leaves. The experiment is a very striking one. Mr. Charles Bullock has prepared some of this salt for this evening, by decomposing the chromate of lead with sulphuric acid carefully added, and, after removal of the insoluble sulphate of lead, neutralizing half the solution with aqua ammonia and adding the rest.

A letter from General Totten, on the subject of a Government Bureau on Mechanical Investigation and Experiment, was read and referred to a Committee consisting of Professor Fairman Rogers and Messrs. Henry G. Morris, William J. Horstmann, James S. Whitney, and J. V. Merrick.

At the conclusion of the Secretary's Report, Mr. John W. Nystrom made the following remarks:

At the last meeting of the Institute, the Secretary, Prof. Morton, stated in his Report on Novelties in Science and Arts that "the analysis of the Red Sea water lately made by MM. Robinet and Lefort, shows its identity with ordinary ocean water, and difference from that of the Dead Sea, thus disproving the supposed connexion of these by any subterranean communication."

It has evidently been supposed that the water would flow from the Dead Sea to the Red Sea, but how can that be possible, when we know that the surface of the former is some 1312 feet, or a quarter of a mile, below that of the latter?

There is one way of explaining the possibility of such water-flow, namely, by the difference of the specific gravity of the waters in the two seas, which is about 20 per cent.

A column of salt water of specific gravity 1·20 in the Dead Sea, of five times 1312 = 6560 feet = 1¼ miles, would balance a column of fresh water in the Red Sea equal to six times 1312 = 1½ miles in height. Adding some depth to the column for head of flow, we have the operation possible, but the question is how the water can become fresh at the bottom of the columns?

It is possible, and even probable, that the salt water is distilled by volcanic heat in some cavities at the bottom of the Dead Sea, from which the fresh water is conveyed through some subterraneous channel to the Red Sea, or some other place. If there exist such a subterraneous conveyance, it cannot be an open free space conveying salt water which could not flow above the level of the Dead Sea, and if salt water was continually flowing out and fresh in, the saltness of the water in the sea could not remain permanent, but would soon become fresh and ultimately melt away the salt banks about the city of Sodom.

The subterraneous communication is likely very irregular, through hundreds of miles of strata of gravel and different kinds of minerals, in which the water would be so thoroughly filtered and rejuvinated, that it could not likely be recognized as water from the Dead Sea, even if taken at the very opening where it may enter the Red Sea.

I have made some calculations of the quantity of fresh water flowing into the Dead Sea in the dry season, and found it to amount to a thickness ($\frac{3}{16}$) three-sixteenths of an inch on the surface, 360 square miles, in twenty-four hours, which would be the amount of evaporation if there is no subterraneous discharge. In the rainy season, the water rises some 15 feet, which, by the before-mentioned rate of evaporation, would require a time of two years and a half to bring the level of the sea down to that in the dry season, and that even without the supply from the river Jordan, whilst the water falls to the ordinary level in some three months, in the coldest season of the year.

This fact seems to indicate the existence of a subterraneous discharge from the Dead Sea.

The supposition that the water in the Dead Sea would become fresh by fresh water flowing into, and salt out of it, is contradicted by the case of the Black Sea, where only fresh water is supplied, and salt water discharged through the Bosphorus into the Mediterranean. The quantity of salt passing through at Constantinople amounts to some 60,000 tons for every twenty-four hours, showing what an immense salt manufactory there must be in the Black Sea, and consumption of the same material in the Mediterranean.

The salt passing through the Gibraltar Straits into the Mediterranean amounts to one million and a half of tons per every twenty-four hours, which would be a chunk of solid salt as large as eight times the size of the Continental Hotel. I am unable to account for the manner in which this enormous quantity of salt is disposed of in the Mediterranean. Some of it may be carried off through some subterraneous channel into the Red Sea.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

A Comparison of some of the Meteorological Phenomena of MAY, 1866, *with those of* MAY, 1865, *and of the same month for* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	May, 1866.	May, 1865.	May, for 15 years.
Thermometer—Highest—degree, .	84·00°	84·00°	90·00°
" date, .	13th.	17th.	7, '60; 23, '63.
Warmest day—mean,	70·17	75·50	79·83
" " date,	27th.	17th.	23d, '63.
Lowest—degree, .	44·00	46·00	35·00
" date, .	3d.	1st, 2d, 12th.	7th, '54.
Coldest day—mean,	50·33	50·50	40·00
" " date. .	3d.	1st.	3d, '61.
Mean daily oscillation.	16·06	13·81	16·93
" " range, .	5·65	6·60	5·58
Means at 7 A. M., .	56·71	59·87	58·53
" 2 P. M., .	67·73	68·91	69·71
" 9 P. M., .	60·10	61·39	61·47
" for the month,	61·51	63·39	63·24
Barometer—Highest—inches, .	29·940 ins.	30·147 ins.	30·338 ins.
" date, . .	8th.	15th.	4th, '52.
Greatest mean daily press.	29·901	30·120	30·273
" " date, .	7th.	15th.	5th, '52.
Lowest—inches, . .	29·156	29·405	29·096
" date, . .	28th.	22d.	27th, '61.
Least mean daily press.,	29·277	29·447	29·243
" " date, .	27th.	22d.	27th, '61.
Mean daily range, .	0·131	0·126	0·121
Means at 7 A. M., .	29·633	29·742	29·795
" 2 P. M., .	29·598	29·708	29·759
" 9 P. M., .	29·628	29·740	29·785
" for the month, .	29·620	29·730	29·779
Force of Vapor—Greatest—inches,	0·694 in.	0·683 in.	0·771 in.
" date, .	27th.	20th.	14th, '54.
Least—inches, .	·128	·143	·069
" date, .	3d.	3d.	2d, '61.
Means at 7 A. M., .	·310	·380	·356
" 2 P. M., .	·324	·389	·372
" 9 P. M., .	·334	·402	·379
" for the month,	·323	·390	·369
Relative Humidity—Greatest—per ct.,	93·0 per ct.	95·0 per ct.	100 per ct.
" date,	17th.	8th.	often.
Least—per ct.,	25·0	24·0	16·0
" date, .	24th.	3d.	5th, '55.
Means at 7 A. M.,	64·1	71·7	70·9
" 2 P. M.,	46·7	54·9	51·2
" 9 P. M.,	62·7	72·0	68·3
" for the month	57·8	66·2	63·5
Clouds—Number of clear days,* .	11	5	10·1
" cloudy days, .	20	26	20·9
Means of sky cov'd at 7 A. M.,	45·1 per ct.	76·1 per ct.	58·6 per ct.
" " " 2 P. M.,	64·2	69·4	61·1
" " " 9 P. M.,	55·2	54·5	47·6
" " for the month	54·8	66·6	55·8
Rain—Amount, ...	4·633 ins.	7·692 ins.	4·816 ins.
No. of days on which rain fell, .	9	13	12·5
Prevailing Winds—Times in 1000,	s77°14′w ·333	s74°17′w ·190	s82°35′w ·122

* Sky one-third or less covered at the hours of observation.